JULY 1957

Journal

VOL. 49 • NO. 7

AMERICAN WATER WORKS ASSOCIATION

In this issue:

Happy July Fourth! Not gun but talcum powder tracing dispersion of hexadecanol in reservoir evaporation control

Journal

AMERICAN WATER WORKS ASSOCIATION

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July 1957

Vol. 49 • No. 7

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918. $7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—60 cents; single copies to non-members—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index*. Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

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Directory of Professional Services—pp. *55-60 P&R*

Coming Meetings

AWWA SECTIONS

Sep. 4–6—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Chief Utility Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 11–13—New York Section, at Saranac Inn, Upper Saranac Lake. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Sep. 18–20—Ohio Section, at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 23–25—Kentucky-Tennessee Section, at Brown Hotel, Louisville, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–25—Rocky Mountain Section, at La Fonda Hotel, Santa Fe, N.M. Secretary, J. W. Davis, 301 Continental Oil Bldg., Denver 2, Colo.

Sep. 25–27—Michigan Section, at Leland Hotel, Detroit. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing 4.

Sep. 25–27—North Central Section, at Gardner Hotel, Fargo, N.D. Secretary, L. N. Thompson, 216 Court House Bldg., St. Paul 2, Minn.

Sep. 29–Oct. 1—Missouri Section, at Sheraton-Jefferson Hotel, St. Louis. Secretary, W. A. Kramer, State Office Bldg., Jefferson City.

Oct. 13–16—Southwest Section, at Skirvin Hotel, Oklahoma City, Okla. Secretary, Leslie A. Jackson, Mgr.-Engr., Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 16–18—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

(*Continued on page 10*)

Coming Meetings

(Continued from page 6)

Oct. 20–23—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Public Service Com., 119 W. Commercial St., Yazoo City, Miss.

Oct. 23–24—West Virginia Section, at McClure Hotel, Wheeling. Secretary, H. W. Hetzer, Engr., West Virginia Water Service Co., Box 1906, Charleston 27.

Oct. 24–26—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Manager, R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 29–Nov. 1—California Section, at Hotel St. Claire, San Jose. Secretary, Henry J. Ongerth, Sr. San. Engr., Bureau of San. Eng., 2151 Berkeley Way, Berkeley.

Oct. 30–Nov. 1—Chesapeake Section, at Sheraton-Park Hotel, Washington, D.C. Secretary, C. J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Nov. 6–8—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–13—Florida Section, at Roosevelt Hotel, Jacksonville. Secretary, J. D. Roth, P.O. Bin "O," Miami Beach 39.

Nov. 11–13—North Carolina Section, at Hotel Sir Walter, Raleigh. Secretary, W. E. Long Jr., State Stream Sanitation Com., Raleigh.

OTHER ORGANIZATIONS

Aug. 5–9—Gordon Research Conference on Ion Exchange, at Kimball Union Academy, Meriden, N.H. Write: W. G. Parks, Director, Dept. of Chemistry, Univ. of Rhode Island, Kingston, R.I.

Aug. 19–23—North Carolina Water Works Operators School, at Duke Univ., Durham, N.C.

Aug. 26–28—Hydraulics Div., American Society of Civil Engineers, at Kresge Auditorium, Massachusetts Inst. of Technology, Cambridge, Mass.

Oct. 6–9—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, at Netherland Hilton Hotel, Cincinnati, Ohio. Write: Albert H. Hall, Exec. Vice-Pres., 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 7–10—Federation of Sewage & Industrial Wastes Assns., at Statler Hotel, Boston, Mass.

Nov. 2–8—World Metallurgical Congress, sponsored by American Society for Metals, at Chicago, Ill.

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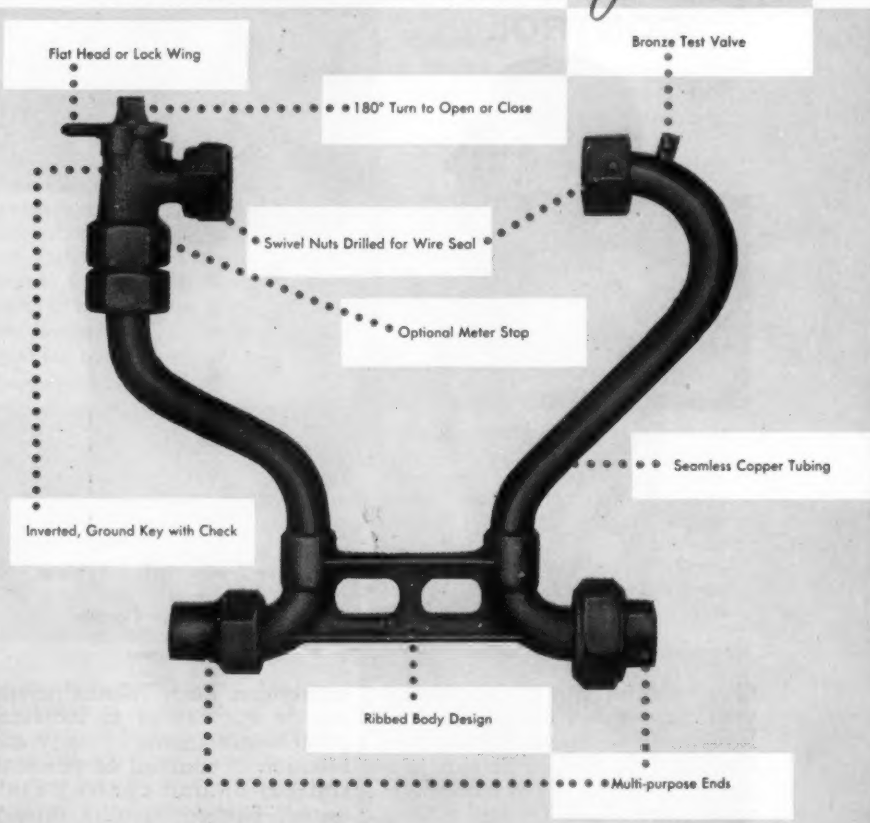

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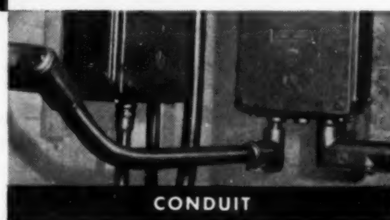
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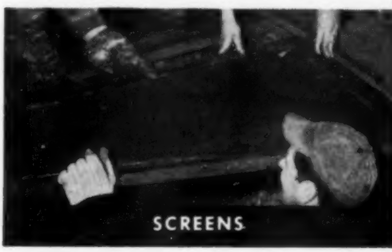
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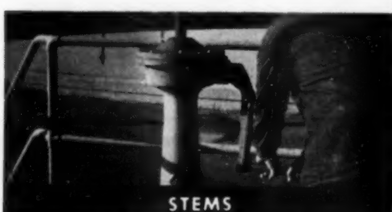
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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • JULY 1957 • NO. 7

Basic Principles of a National Water Resources Policy

Committee Report

A report of AWWA Committee 1130—National Water Policy, submitted on May 15, 1957, at the annual conference at Atlantic City, N.J., by Abel Wolman, Chairman, Cons. Engr., Baltimore, Md. Other members of the committee were: A. P. Black, E. S. Chase, L. H. Enslow, C. H. Bechert, G. E. Ferguson, S. B. Morris, N. T. Veatch, and W. V. Weir.

Preamble—*Abel Wolman*

I FEEL that I must almost apologize for talking about national water policy, because, actually, there is no such thing. Thus, before presenting the formal report of the AWWA Committee on National Water Policy, I want to make a few remarks, more or less historical and perhaps philosophical, with respect to the subject of the report. In making these remarks, I am not speaking for the committee, but strictly personally.

It is approximately a quarter of a century since the first formal statement of a proposed national water policy was made in the mid-1930's by the Water Resources Committee for the then National Resources Committee of this country (*1*). That statement of national policy was predicated upon an assumption which we should now look at hard and critically. *The assumption was that we needed on the national level and, of course, on the state and local level a water policy which was uniform and equitable.* Those who have pursued this subject and read its vast literature will note that throughout all subsequent discussions, throughout all subsequent official and voluntary association reports, this assumption—that we need a more uniform and equitable water policy—has stood its ground for almost a quarter of a century.

Past Policy Statements

In this first document, it was stated in round terms—and in what could almost be called beautiful literary style—what this uniform and equitable water policy ought to be and what should be embodied in it. These basic points were spelled out in the first document of the National Resources Committee of which I had the pleasure of being a chairman for a period of about 8 years. The literary quality was provided by one member of the Committee at that time, Professor Harlan H. Barrows, then head of the geography department at the University of Chicago. I still think it is an explicit and clear statement of what such a policy ought to be—if you accept the basic assumption.

The Water Resources Committee statement was followed by a series of official reports, the first of which was the President's Water Resources Policy Commission report of 1950 and 1951 (*2*). This has great significance, not only because of the bulk—its three volumes included more than 2,000 pages—but because it represents one of the finest bibliographical contributions to water policy discussion in this country. It should be on the desk of every individual who has even the remotest professional interest in this subject.

This commission was both preceded and followed by the first Hoover Commission, formed in 1949 with a broader assignment than the water resources group. The Hoover Commission's assignment was to cover the reorganization of the national government as a whole, but no small part of its effort and its contribution dealt with the water resources problem (*3*).

In 1951 the Materials Policy Commission was created by the President of the United States and struggled for well over a year, on a very broad basis, to deal with our problem of total resources. Again a significant portion of its report (*4*) dealt with water resources policy.

The second Hoover Commission followed in 1955 and it worked for almost a year and a half with a fine and extensive technical staff, again producing a whole shelf of volumes, anyone of which would be worth rereading if anyone were inclined to familiarize himself with the history of water resources (*5*).

Sixth in the series of documents followed in 1956, and was presented by the President of the United States to the Congress as a report of the Presidential Advisory Committee on Water Resources Policy (*6*). It was filed with President Eisenhower in December 1955 and submitted to Congress in 1956. It had the great advantage of being concise—instead of a shelf, instead of a thousand pages or more, it was a mere 35 pages, highly readable, very much crystallized, and generally following the same pattern of enunciating water policy that was employed in the preceding five reports.

In addition to all of these, many, many national water policy documents have been prepared by voluntary groups—professional engineering associations, semiprofessional organizations, and pressure groups. The libraries are filled with such statements, which carry essentially uniform policies throughout the total period of about 25 years.

The Engineers Joint Council report of 1951 (*7*) has a special significance, because it was the result of almost a year's deliberation by well over 80 professional engineers. It had the further distinction of representing a great deal of engineering work without reimbursal. It is one of the outstanding examples of engineering contribution

to this country—the contribution of a great amount of devotion, time, and effort. The 1951 report has since been reviewed and revised, a new document (*8*) having been approved in April of this year.

The AWWA itself has had a water policy committee for many years, as has the American Public Power Association. The United States Chamber of Commerce through its Natural Resources Committee has made a whole series of reports. The National Water Conservation Association has taken a stab at this problem, and so has the National Reclamation Association. The Rivers and Harbors Congress has met regularly over the years and has deliberated on these policies and issued statements following, in general, the same basic principles as others, deviating therefrom only in the directions that seem helpful to some of the pressure groups involved.

It is well to be aware of all these policy statements, because, with all the work, with all the deliberation, and with all the participation by myriads of professional and lay groups for almost 25 years, the sum total of the accomplishment in the translation of these policies into congressional policy and action, if not exactly zero, is almost zero.

I give this as a preface to the added contribution today of AWWA's own water policy committee. This new policy may at least be considered to have distinction in that it is only three pages long. Perhaps this reflects the fact that we may all be getting relatively tired of reproducing these principles at length. More significantly, however, I preface the presentation of the document by questions which are directed to AWWA's own committee and to all interested in the subject. Why have all of these carefully phrased statements of national policy never been translated into reality?

I am not sure that I have the answers. I would pose questions—perhaps three or four of them—largely for the reflection of those of us who continue to operate in this field.

Was a Policy Needed?

The first question that must arise, of course, as one looks over this great library of exposition is whether a policy was really needed. That seems a disheartening question to ask after a quarter of a century, after the devotion, after the recording of the hearings, after the tremendous unpublished record on file in Washington. Was a policy needed?

It would appear that if it was needed it was not wanted. It was not wanted by the only people in the country who could create such a policy—namely, the Congress of the United States. Up to today, it would be my comment, reading between the lines and having attended congressional hearings, that Congress does not want a carefully framed water policy.

A secondary question, of course, stems from that: Why does it not want a policy? I would guess that it does not want a policy because it would consider it as an interference with its liberty of action. You might say that I have phrased it, if not happily, at least too philosophically. What I mean by it, of course, is that they do not want a policy that might interfere with sectional choices, with pressures, with political favor, with advantages for one area against another. In other words, there appears to be a latent hostility to a uniform policy and there is more than a latent hostility to an equitable fiscal scheme. Anyone who has reviewed such policy as we have exemplified in national practice will find we have

every conceivable system of financing that anybody could conjure up.

The most recent, of course, are strange, unless you bear in mind that this strangeness stems from the fact that we are always in search of a fiscal policy which will not require the beneficiary to pay for what he gets, but will give a semblance of doing so. The vagaries of that semblance over the last 100 years are extremely entertaining if one takes time off to look them over. We, of course, now have reached the stage where the beneficiary pays for something at some remote century deferred in some remote and complex formula which, I feel quite sure, ends in his paying not an original 100 per cent, not an original 50 per cent, but, in some major enterprises, closer to 5 or 10 per cent of his appropriate cost.

Now, I hasten to add as an observer, that that may or may not be an objectionable national policy. I make the point that, in all these matters, we must remember that we live in a democracy in which decisions must be democratically made. They may seem at times to be either unintelligent or abstruse or pressure stricken, but they are still made by the only body that can make them—the Congress of the United States. So much for my first question—was a policy needed?

The record would seem to show that if it was needed, it was not needed badly enough by the appropriate democratic representation—by Congress, that is. I think the answer is inevitable. If it had been needly badly, I am sure the need would have been converted into a statement of policy.

Was It Too Early for a Policy?

The second question is: Was it too early? Maybe those who follow us, and I mean chronologically as well as professionally, will find that these enunciations of policy are just due to the temper of the time and that they will have to come into action in greater degree than in the past. Perhaps that may happen because of the acuteness of pressure for a policy, the competition for water, or the better understanding of the increasing necessity for a policy.

In a country such as ours, where even water resources may come under greater pressure in the next quarter of a century, the situation may drive us toward a policy which we have not yet been able to convert into congressional behavior. It may actually be that in most countries, including our own, one will not frame a policy or convert it into action unless there appears to be not only a reason for doing so, but a dramatic reason for doing so. In other words, we must begin to see the penalty of not doing so before we are willing to accept a policy.

Were Our Policies Unrealistic?

The third question is—and this, I would, perhaps, give only in a whisper because it is a reflection on our own professional activity: Were all of our documents truly unrealistic? I think in some instances they were. I would say, for example, that part of the most recent Hoover recommendations—say, on public power—to my mind were unrealistic. The suggestion, for example, that we undo everything that has been done in the United States over the last third of a century seems to me to be unrealistic. You may have, and I may have, many philosophical reasons for feeling it should be done if we lived in a vacuum, but I doubt very much if you could practically consider so turning the clock back and obtaining the acceptance of Congress and its constituents.

We may have been too unrealistic in

many of our professional recommendations. The hardheaded, hardbitten congressional representative who goes back not only to mend fences, but also to create them, may have looked at these documents sometimes with a jaundiced eye. He may have written them off as being the kind of theoretical hopes of a group that did not quite know its way around. I could lift out other examples of such principles that, in retrospect, would seem to me to have some degree of lack of reality.

Whether or not we would ever recapture principles which we still consider to be sound within that framework, I am not the one to prophesy; I have some serious doubts as to whether we will ever recapture some of them—for instance, that the navigation work of our federal government should be put on a pay-as-you-go basis. I myself have very, very limited hopes that that will ever happen. I could spell out why I think those hopes are so limited. It does not mean that I would not continue to add my signature to the recommendation.

How Much Organization?

The last question is the fundamental issue in all national policy. Bertrand Russell, many years ago, in the title of one of his books, reflected on this when he captioned it: "Freedom Versus Organization," his point being the question of whether a society can be operated in which those two requirements are continuously embattled with each other. How much organization, which is enunciated in our ordinary policy principles, will a democratic country accept? How much does it want to insist that it improvise as it goes along? How many ad hoc decisions does Congress feel it must insist on reserving to itself?

I do not smile at that conflict, because, in some respects, it may lie at the root of our democratic approach even to water resources development, and there is, of course, again this little whisper underlying the battle between freedom and organization in which we stand for an organized approach to this development. It must be whispered that there are enough evidences in the past that the professional has been wrong, that the professional on occasions has not been as deserving or intuitive perhaps as the best politician or statesmen, and that, too, must be remembered.

I recall an incident with respect to Grand Coulee before construction was started, during efforts to determine whether or not the National Resources Planning Board would ratify a recommendation that the Grand Coulee Dam be built. On the train, going up with Frederic A. Delano—board chairman, and a very wise professional engineer and statesman—we discussed the question of whether the dam might be deferred for 20 years or more. In other words, the return did not yet seem to warrant the investment. Mr. Delano made the interesting observation at that time that sometimes you construct a project in order to generate a return when the return is not visible.

He called my attention to the fact that we would have turned down Alexander Hamilton's proposals, as they were turned down by many professionals, when he suggested that the New Jersey area be developed for power. He was scoffed at because the area was strictly agricultural in nature at that time. Everyone wanted to know where the power user was. And, of course, the user was nonexistent. Alexander Hamilton stuck to his guns, as the people in New England did—the Fred-

erick Stearns and others—who said that if we developed power in New England we would generate the customers, which, of course, happened. This is the history of the two most heavily industrialized areas in the United States and, as Mr. Delano reflected, one can go wrong in waiting until the customer is there.

You will remember the city engineer of Los Angeles who had the same breadth of vision when his community had less than 100,000 people. It was he who made the trenchant remark that if you wait to bring the water here until you need it, you won't need it.

AWWA's New Policy Statement

It will be well to keep these four questions in mind in reviewing the following statement on national water policy which stems from the AWWA policy committee. It is an attempt in three pages to bring to your attention once more, and to the attention of Congress and all thoughtful citizens, that there is room for the adoption of a sound water resources policy—moving toward equitable distribution of costs; a far greater uniformity of approach on the federal level; a strengthening of state and local participation; an attempt to stem the tide of having all money come from Washington; and an attempt to spell out the desirability of preserving both local interests and local financing, if for no other reason than to bring the expenditure of money closer to the local pocket. The local taxpayer is generally a little bit more thoughtful and, I would say, generally a little bit more guarded, about the expenditure of his tax money locally than he is about his federal taxes. It is the remoteness that disguises federal tax moneys and identifies them with a kind of Santa Claus in Washington.

In pointing this out, however, I want also to note that in its statement of policy the committee again reinforces its emphasis for supporting those federal agencies, such as the United States Geological Survey, in the extension and the intensification of their collection of basic data and their orderly interpretation of such material. In a vast country such as ours, the future will demand more rather than less of that kind of federal participation—what we call the groundwork of most of our studies—than it has ever done in the past. We need the cooperation of all local, state, county, and federal people in this type of federal activity which we feel must have national perspective and emphasis. Of course, such activity will require a far greater degree of financial support than it has ever had in the past. That kind of federal activity lies at the root of anything with which engineers deal, and must be, as I say, extended geographically and professionally, and interpreted to our major benefit.

This preamble has been lengthy, but insofar as the preamble is a review of our failure to move into reality, it is, perhaps, almost as important as the policy statement itself.

AWWA Statement of Policy

So much has been written in the past 10 years regarding water policy that the committee hesitates to add to the bulky volumes already on the library shelf. The reiteration of principles and policies with extensive expository supporting data no longer appears either appropriate or helpful. The present report, therefore, is restricted to a simple summary of the general principles which, it is believed, offer a reasonable basis for the development of the water resources of the country:

1. A sound water resources policy must look toward an adequate supply of water for our people; prevent waste; reduce pollution to its lowest practicable level; provide means for the best and most effective distribution of water; and take steps to check the destructive forces of water which destroy land, property, and life.

2. First priority should be given to providing water for people—for use in their homes and urban activities. The relative status of industry, agriculture, recreation, and navigation depends upon the contribution which each can make to the economic and social welfare of the area or region concerned.

3. The successful administration of a national water policy is dependent upon adequate basic hydrologic data and increasing emphasis upon the interpretation thereof. These, in turn, are dependent upon a greater understanding of the natural laws governing the occurrence, movement, availability, and conservation of the nation's waters. The US Geological Survey is entitled to full support in its water resources activities.

4. The position of a federal coordinator of water resources should be established in order to provide presidential direction and agency coordination and to establish uniform principles, standards, and procedures for planning and development of water resources projects in which there is a federal interest.

5. A board of review, independent of other federal agencies and under its own chairman, should be created to analyze the engineering and economic feasibility of projects, to determine the federal interest in them, and to report to the President and the Congress. Appointments to the board of review should be made for such terms that a majority of the members are not appointed during a single presidential term of office.

6. Regional or river basin water resources committees should be formed with a permanent nonvoting chairman appointed by the President, with membership composed of all federal departments and states involved, *provided* that the states paramount control in matters involving intrastate waters is maintained.

7. A permanent federal interagency committee on water resources, advisory in character, composed of principal policy making officials of the agencies concerned, should be established under the chairmanship of the coordinator.

8. Planning for water resources and related developments on interstate streams should be conducted on a cooperative basis with representatives of all federal, state, and local agencies involved. This joint participation should

be continuous in order that the plans and projects development assure the best and most effective use and control of water to meet both the current and long-range needs of the people of a region, state, or locality and of the nation as a whole.

9. The federal government in its activities in the water resources field, should:

9.1. Provide for the preparation of plans for the unified development and regulation of the interstate river system of the country upon sound hydrologic, engineering, and economic principles.

9.2. Provide for definite and effective programs for the construction of the projects included in such plans, the programs to be prosecuted as found desirable by Congress to meet current necessities which are in the national interest.

9.3. Limit federal contributions toward projects to amounts warranted by the national interests involved.

9.4. Provide for an equitable distribution of project costs among various functions and various beneficiaries.

9.5. Provide for systematic and effective cooperation among federal agencies—and between these and agencies or individuals in the several states—in formulating water plans and programs.

9.6. Encourage the state and local agencies to assume full responsibility for planning, constructing, and operating their water resources projects and, when working in cooperation with the federal government to assume their appropriate share of all allocated costs.

10. As a general policy, all interests should participate in the cost of water resource development projects in accordance with the measure of their benefits.

10.1. The federal government should assume the cost only of that part of projects where benefits are national and widespread.

10.2. Beneficiaries of federal water resources projects should reimburse the federal government (with interest on any deferred payment) for their equitable share of the cost.

10.3. Where projects are primarily local, and the beneficiaries are clearly identifiable, the federal government's contribution should be limited, with nonfederal beneficiaries bearing equitable portions of the construction costs of the project, as well as the replacement, maintenance, and operation costs.

11. The states should fully exercise their rights and responsibilities in the control and development of water resources.

11.1. State legislation should be enacted in due time to provide a basis for the equitable settlement of the problems inherent in each phase of water development and management. Premature legislation, however, tends to perpetuate past use patterns because of their residual political weight. Therefore, each state should be cautious about adopting features of statutes of other states. A new statute should instead be based on a full knowledge of the water problems to be encountered in the state involved. The hydrologist should be an equal partner with the lawyer and the economist in the design of legislation.

11.2. The state should, by appropriate legislation, encourage and, when necessary, foster the construction of storage reservoirs for control of flood runoff where need is demonstrated. Any water thus stored should be under the jurisdiction of the state allocation agency and should be made available for such use as will promote the greatest economic benefits.

11.3. The states should enact legislation which will permit and encourage the development of water districts, water authorities, or similar agencies (not limited by municipal or county boundaries) for the development, production, treatment, and distribution of water for domestic, commercial, industrial, municipal, and fire protection uses.

11.4. The initiative and responsibility rests upon local agencies for planning, financing, constructing and operating works for furnishing domestic, commercial, and industrial water supply. The federal government should not participate in such projects unless they are a part of a multiple purpose water development in which there exists definite and justifiable federal interest and benefits.

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Municipal Utilities and the Fringe Area

George H. Esser Jr.

A paper presented on Nov. 13, 1956, at the North Carolina Section Meeting, Charlotte, N.C., by George H. Esser Jr., Asst. Director, Institute of Government, University of North Carolina, Chapel Hill, N.C.

DURING the next 25 years, all reliable estimates indicate, 50,000,000 more people are going to be living in our cities, in suburban communities, and in what we call, for lack of a better term, urban areas. North Carolina cities and urban areas will get their share of those 50,000,000 people, and, perhaps, more than a proportionate share if the present campaign for industrialization is accelerated. Only during the last few years have those in urban areas fully realized the challenge that must be faced in the next 5, 10, and 20 years—the question of how those 50,000,000 people are to be given jobs, how they are to find attractive homes served by adequate governmental services and a community situation in which they can lead happy and satisfying lives. This is a large order and it must be filled without penalizing those who live in cities today.

During the last 3 years, as recognition of the challenge has grown, communities have begun to respond. Intensive studies of many growing cities have been undertaken; universities have placed metropolitan development high on the research priority list; private foundations and public agencies have begun to pour more and more money into the effort to find better answers for government in the growing metropolitan and urban areas.

But all this effort comes at a time that is already occupied with development. Today and tomorrow and the next day, utility and government officials all over the country must make decisions which will have a lasting effect on how and where cities will develop. While research goes on, life goes on, and it is not possible to wait for the answers that 1962 will bring when confronted with the problem in 1956.

It is not necessary to spell out the problem. The population of some North Carolina cities is increasing as much as 3–5 per cent per year and the population of fringe areas outside of those cities is growing at a faster rate. New homes are springing up in clusters of 2, 5, 25, 100, and 500. Residents of these new developments who want the best services they can obtain at the lowest cost often make judgments based more on cost than on needed quality of services. Every city in North Carolina has outside its borders new housing developments which are served with wells and, more frequently, with septic tanks—where lots are too small to provide adequate sewage disposal with such a tank. Inadequate sewage disposal results in a hazard to public health, in loss of property values, and in the creation of suburban slums. It does not take years for these conditions to develop; if building takes place today under these conditions, the danger stage may come by next year. These are just sanitation

problems, but there are countless others.

These conditions do not arise because of the unwillingness of water and sewer departments to cooperate; indeed, they arise in spite of the efforts of municipal officials. In order to avoid such conditions, many cities have made water supply, in particular, and sanitary sewer services, in some instances, available outside corporate limits. So that city taxpayers will not suffer from making this privilege available outside city limits, cities have charged higher rates to users outside the city and, all too often, cities have received in return the antagonism of outside residents rather than their gratitude.

It is not the object of this article to discuss or analyze the specific policies which cities should put into effect when extending water and sewer services to outside residents. Many cities have sound financial policies in this respect. In other cases, however, it is felt that cities are unjustifiably subsidizing development in outside areas at the expense of the city taxpayer.

A detailed study of Greensboro, N.C., and its suburbs made by the author in 1955 under the auspices of the Institute of Government of the University of North Carolina provided conclusions of value to all cities. Although this article is based on conclusions drawn from the Greensboro study, it is not the last word on the subject. It is hoped to refine and make more practical these conclusions with any comments and suggestions which may be forthcoming.

Local Government Objectives

First, it seems necessary to discuss the overall policy objectives of local government, particularly with reference to water and sewer services. This cannot be done without looking at the entire metropolitan area—the city and its suburban fringe—for if the corporate boundary is eliminated, an urban area remains that has no boundary short of the open country.

A primary objective, it seems, is to get adequate services to those who need them when they are needed. If this objective is applied to water and sewer services, it means the installing of water and sewer lines at the time the land is subdivided into small lots on which homes are being built. For example, if a subdivision of 100 homes is built on lots 75 by 100 ft within a mile of a city, it is clear that septic tanks will not be adequate for sanitation. Community sewage disposal systems may be more adequate but do not constitute a long-term solution. It is desirable that a subdivision of this character be connected to a public sewer system when it is built, not after it has been equipped with septic tanks that have proved inadequate.

But this objective is stated in general terms. To what extent should it be necessary for a city to extend its water lines? How far into the suburban area does a city have basic responsibility? These are questions that have puzzled many, and no flat answer can be made. In the Greensboro study, however, a standard was assumed which made approximate answers possible. This standard was based on density and was developed as follows. From standards and studies of health officials, including the county board of health, it was determined that individual sewage disposal systems would not work satisfactorily unless they were used on lots of about 0.5 acre or larger in size. Fortunately, and not entirely by accident, it was discovered that the city could afford to extend tax-supported services—

fire and police protection, garbage collection and disposal, and street maintenance—to any area that was developed, on the average, to a density of about two houses per acre. This was also the density at which the city could afford to extend water and sewer lines under the city's rate structure and extension policies.

Optimum Density

It was clear that a high level of services could be financially supported in the Greensboro suburban area wherever development was at this density, which was also the density at which the public health officials required connection to the sewer system. In short, if development in the metropolitan area could be guided properly, city type services could be supplied to those areas having a density requiring such services; in more sparsely developed areas, a less expensive pattern of services (including wells and septic tanks) would meet health requirements and other service standards.

The exact findings in Greensboro will not be duplicated in every city, but the pattern will probably be similar. Property tax conditions in some of the counties will make it difficult for every city to provide high-quality services to land having so few houses per acre, but in other cities service costs will be much lower than in Greensboro.

As is known, however, there is a general tendency to build subdivisions and little communities at 1, 2 and 3 miles from the city, where the land is cheap. This sprawling development makes extension of municipal facilities prohibitively expensive, and suggests a second policy objective: If cities are to extend services where and when needed, development of a community of that type and density which requires city quality services must be restricted to the area that the cities can reach. This is not to say that the city must determine which land is to be developed, but that the city, in conjunction with other governmental agencies, must encourage intensive development where services can readily be made available.

Ideally, then, two objectives are desirable: [1] It is desirable to prevent the development of suburban slum areas—slum areas being those which result from inadequate sanitation, inadequate water supply, or unsound land development. [2] It is desirable to channel suburban development in such a fashion that prohibitive costs for municipal services are not incurred. Both of these objectives imply one major goal—that the entire metropolitan area be soundly planned, particularly since the type of development that takes place outside the city is of great importance to the people now in the city.

Unity of City and Fringe Area

Unless the fact of the unity of the city and fringe area is accepted, there is no fringe area problem. The city has the closest possible interest in development outside the city for a number of reasons. The corporate boundary is, in effect, an imaginary line which cuts through a community which is in reality a single economic and social unit. Businesses outside the city depend on a market inside the city, and businesses inside the city depend on the outside market to an even greater degree. Residents outside the city work, shop, and play in the city. If the greatest good of all who live in the community is to be met, then local government policies must be planned to encourage economic development throughout the metropolitan area. Industrial develop-

ment must be encouraged with good sites, good transportation and utilities, and attractive residential areas; commercial development with good sites, good transportation, and a good market; and residential development must be encouraged with good sites and good services.

Furthermore, the *incorporated* city has an interest in development outside the city. It is established that small, growing cities (such as those in North Carolina) cannot stop extending their boundaries and continue to have a tax base which will support the ever increasing demand for services. This is particularly true when many of the demands on our cities and towns are for services benefiting the suburban resident as well as the city dweller. The city dweller cannot be expected to continue to pay for wider downtown streets, special downtown fire protection, and special traffic control measures if additional revenues are not made available. If cities must grow, if they must extend their boundaries, then conditions outside the city must favor annexation and make the cost of annexation as low as possible. If cities do not grow, they will soon reach the point of decreasing revenues at a time when service demands are still increasing. In short, the fringe area problem is not confined to the suburbs; it is just one part of the picture of metropolitan development.

North Carolina cities cannot reach the objective of encouraging sound metropolitan development overnight. These cities do not have the power, alone, to reach this objective or to solve their fringe area problems. They can, however, make a good start by understanding their own areas and, then by adopting an overall program leading to a solution. Water and sewer system personnel must be in the vanguard when that program is adopted.

Long-Range Planning

The steps necessary to enlarge a water supply or filtration capacity, or to build or rebuild a distribution system or sewage disposal plant are familiar ones. The first essential step is a study, as it is, too, in planning for the growth of city services. The study need not be made by an outside agency; indeed it may be preferable to make the study locally. Whoever makes it, however, such a study should include anaylsis of:

1. The probable future economic development of the city and the surrounding suburban area

2. The probable population growth in the city and in the surrounding suburban area for the next 20–25 years

3. The services which will probably be needed both in the city and in the suburban area during the same period

4. The cost of providing those services and the revenues which will probably be available to meet them

5. The policies which will be necessary both on the part of the city and of the county in order to encourage economic development and meet service needs.

Such a study should not be made by the city alone. It should be made with the assistance and participation of residents in the suburban area and of the county. Some cities will get more understanding and cooperation from its suburbs than others, but the effort must be made to enlist that cooperation, because the best job cannot be done by the city alone.

On the basis of the study, a program should be developed that is appropriate to the city and the metropolitan area.

One of the first points in a program should probably be a well-defined annexation policy. With all deference to the cities which are now extending water and sewer services to the suburban area without annexation, it would seem that such a policy is, in effect, selling the city's birthright for a mess of pottage. Of course, it is true that water and sewer services are financed by rates and charges and that the remaining city services are supported by taxes. It is also true that water lines and, less frequently, sewer lines can be extended more easily than the other services. City services are, however, interdependent. A high quality of fire protection is not possible without water lines. An outside resident who is served by city water and sewer lines benefits from some of the values of city fire protection (such as lower insurance rates) without paying taxes for the privilege. In other words, when he receives water and sewer services, the outside resident gets an important part of the municipal service package—the part that makes his property more usable and more valuable. The city, which must eventually expand, gives up its bargaining position in advance. The outside resident, while enjoying the principal city services and while working in the city, expects the city taxpayer to provide him with police and fire protection at his place of work, expects the city taxpayer to rebuild and widen the streets that take him to and from work, and expects the city taxpayer to provide the recreational facilities which he and his family can use.

Annexation

Instead of surrendering its bargaining position, the city should use it. This is not to suggest indiscriminate use; rather, it would seem practical, as part of an overall city-suburban plan, for the city to make its services available to any area which is being developed for commercial or industrial uses or for high-density residential uses. As a prerequisite to such service, however, the city should insist that the area be annexed prior to extension of services.

More and more cities are adopting this policy today, and it is being used successfully because these cities (in North Carolina) are showing the new homeowner that he will benefit from annexation. But there are many questions that can be raised concerning the long-range workability of such a plan. What, for example, can be done about the area which refuses annexation and installs septic tanks? It must be reemphasized at this point that cities cannot do the job alone. Many devices have been suggested. County-wide planning and a county subdivision ordinance can help. But just one thing will work in the long run—controls that prohibit development in a way that will create sanitation hazards. These controls can be imposed in North Carolina today. If the county board of health were to tighten its regulations for the installation of septic tanks, there would be two results. First, those areas where large subdivisions were being built, or where commercial centers were being built would have to be located where city water and sewer services were available. Secondly, if construction were done without city water and sewer services, builders would be compelled to operate under regulations which would probably insure satisfactory operation of septic tanks. In Guilford County, the health officer and the author agreed on a minimum lot size of 20,000 sq ft.

Effects on Real Estate

Another question which might arise concerns the danger of upsetting the real estate market by attempting to locate all development adjacent to the city boundary. Stringent septic tank regulation will distort the real estate market unless the city is willing to extend water and sewer lines into an area which has at least twice as much land as is needed for development at any one time. This means that the city must first have a water rate structure that will support a reasonable amount of extension each year, and it must let its extension policies be known.

There are several sound and successful extension policies in effect today in North Carolina. Fundamentally, though, there are only two feasible choices. Either the city can adopt a limited utility concept and offer to pay part of the cost of extension to any newly served lot (in cash or through a refund), or the city may adopt the property benefit concept and assess part or all of the cost of the installation of local lines against the abutting-property owner. In any case, it seems that the city should bear the cost of trunk lines and major distribution or collection costs. At this point the rate structure should be defined. A sound rate structure is one in which the rates meet the costs of production and distribution of water and the collection and disposal of sewage, and leave enough annually to amortize the cost of extending lines in proportion to community growth.

Each of the two principal extension policies has some advantages. The assessment of some costs has advantages in that it recognizes the increase in property value which derives from the installation of water and sewer lines, and in that it requires a smaller investment by the city. The limited utility concept has advantages in that it may encourage connections, because it apparently requires less investment by the property owner.

New Annexation Procedures

Service to areas adjacent to the city, but which will not approve annexation is another problem. Under the present law, there is no way to force annexation, and forcible annexation is not recommended unless there is a *quid pro quo*. When water and sewer lines are installed in an area, the property in the vicinity increases in value. When those lines are installed, the remaining city services become feasible. In short, the extension of services is extension of the service boundary, and the service boundary should coincide with the corporate boundary. After all, the high-quality services provided by a city are only those services needed in a relatively densely populated residential or commercial area. When these services are made available, the area served should be part of the city. In order to insure that services are provided when they are needed and that annexation takes place on a rational basis, it would be useful to enact legislation providing for statutory standards which establish when an area should be annexed. The city might petition for annexation whenever it was ready to extend water and sewer lines into an area. The petition would be made to a board representative of the entire metropolitan area whose function it would be to determine whether the petition met the statutory standards.

Such a procedure could work in North Carolina. It has not been refined, but it is being studied carefully, and perhaps a specific proposal that takes into account the necessary safe-

guards and exceptions can be prepared for submission to the 1959 general assembly.

Industry which does not want to be annexed presents a difficult problem. If an industry is receiving municipal services, however, it should be willing to pay for them. If it does not want the services and is not receiving them, perhaps an exception can be made. Further intensive study of this problem of industrial location and service must be made if any state expects to be attractive to industry. Local governments cannot, however, afford to subsidize such industry—even indirectly.

Conclusion

The fringe area problem can be solved, but only through a carefully coordinated program in which the city, the suburban area, and the county government cooperate. The following could serve as interim measures: [1] community studies; [2] public relations programs initiated by cities; [3] refusal on the part of the city to extend water and sewer lines except where the area to be served is annexed; and [4] a water and sewer extension policy that is financially feasible. It is not denied that many problems may appear not to have been covered in those simple words, but these problems can be worked out. Above all, cities must take the initiative in planning for the rapid growth that has already begun, and water and sewer personnel must take a leading role in helping to work out a practical policy.

Use of Monomolecular Layers for Reservoir Evaporation Reduction

Lloyd O Timblin Jr., Willis T. Moran, and Walter U. Garstka

A paper presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J., by Lloyd O Timblin, Jr., Physicist, Willis T. Moran, Engr., and Walter U. Garstka, Engr., all of the Bureau of Reclamation, US Dept. of the Interior, Denver, Colo.

EVAPORATION and its reduction are important to the Bureau of Reclamation from several standpoints. In planning a project, the evaporation from a proposed reservoir or series of reservoirs must be evaluated in estimating potential water loss. Evaporation loss may be significant or even critical, particularly when a large number of reservoirs is involved or with reservoirs having large holdover storage. In existing projects this loss of water may be prorated among the water users according to legal decisions, as in the North Platte River system of Colorado and Wyoming. Any reduction of evaporation loss increases water available for use. In the arid West, prices of irrigation water range from \$1 to \$20 per acre-foot, depending upon the location. In the West, irrigated land under average management may yield produce valued from \$30 to more than \$200 per acre.

The evaporation of water is a serious problem not only in the West but also in many humid regions of the East. The loss by evaporation, however, however, is less evident in humid regions because rainfall nearly equals evaporation. Hence, any method reducing evaporation benefits not only the arid West, but other parts of the country as well.

Monomolecular Layers

Laboratory studies during the last 60 years (*1–7*) have shown that monomolecular layers of certain long-chain polar materials are able to effect a significant reduction of evaporation from a water surface. The layers are produced when the molecules align themselves with one end (the hydrophylic end) in and the other end (the hydrophobic end) out of the water. Such films, because they are confined to the water surface, may behave as two-dimensional liquids, gases, or solids. The presence of these layers can substantially reduce the surface tension. A useful concept based upon this reduction is film pressure, which is the difference between the surface tension of clean water and that of a surface covered with a film. Values of film pressures range from nearly zero to over 40 dynes per centimeter.

Field studies in Australia have shown that long-chain alcohols, particularly hexadecanol, show promise when used as a monomolecular layer for reservoir evaporation reduction. Further studies are now underway, not only by the Bureau of Reclamation, but also by several other organizations in this country, as well as abroad.

Fundamental Studies

E. K. Rideal (*4*) was the first to observe the reduction of evaporation of water by the presence of a monomolecular layer. His studies, done in 1925, were made with various fatty acids. Langmuir and Langmuir (*5*) extended the studies of Rideal and found that, with regard to reducing evaporation from a water surface, hexadecanol was superior to oleic, stearic, and palmitic acids, as well as to cetyl palmitate and myricyl alcohol. These investigators were the first to propose the use of a resistance value to express the ability of a given monomolecular layer to reduce evaporation. The evaporation resistance for a given film is a function of the reciprocal of the mass transfer rate of water through the film.

A most important work was reported in 1943 by Langmuir and Schaefer (*7*). In their experiments, the evaporation from a water surface was measured by the amount of water absorption in a desiccant located a few centimeters above the treated water surface. The true rate of escape of water molecules from the surface was decreased by a ratio of about 10,000:1 by a compressed monomolecular film of hexadecanol. Modifications of this technique have been used for laboratory studies by most of the investigators since that time. They noted that the contamination of one part in 1,800 of certain organic materials in the monomolecular layer could reduce the effectiveness of a layer to 40 per cent of its original effectiveness. They discussed the mechanism by which the evaporation was reduced and contrasted it to the ability of a thick layer of oil to reduce evaporation, in which case there is simply slow diffusion through the oil. With a monomolecular layer, there is a finite energy barrier to be overcome by the escaping water molecules.

In 1953, W. W. Mansfield (*8*), investigating the use of monomolecular layers under field conditions found that hexadecanol, and possibly stearyl alcohol, were most effective.

In 1954, LaMer and Archer (*9*) reported on investigations with fatty acids. Their results were expressed as a modification of the Langmuir-Schaefer resistance. They were able to demonstrate that liquid monomolecular layers of the fatty acids give a resistance which is independent of the film pressure when it is above 10 dynes per centimeter. They offered an explanation for the energy barrier postulated by Langmuir and calculated its magnitude from the heats of vaporization—with reasonable agreement with experimental results. They also demonstrated that the effectiveness of a given film is dependent upon the spreading technique.

The early studies of Cary and Rideal concerning the production of a monomolecular layer from solid material were confirmed in 1955 by Mansfield (*10, 11*). In particular, he was most interested in hexadecanol and stearyl alcohol and found, as did the previous investigators, that the rate of formation of a monomolecular layer from a solid was a function of the length of the air-water-crystal interface and the difference between the instantaneous film pressure and the spreading pressure for the material. He also was able to show that fatty acids, when applied to natural bodies of water, combine with the chemicals in the water to form a solid monomolecular layer—that is, a film which shows horizontal shear strength. Such solid monomolecular layers do not exhibit

the ability to reduce evaporation. This probably results from the fact that the slightest movement of water fractures the film causing openings which do not reheal. On the other hand, he found that the monomolecular layers of the alcohols remained as two-dimensional fluids when applied to the water surface of outdoor lakes or reservoirs. From these observations he concluded that fatty acids, as a group, are not practical for reservoir evaporation reduction.

LaMer and Rosano (*12*) continuing the previous work by LaMer and Archer, reported their investigations with long-chain acids and alcohols. They were able to correlate the ability to reduce evaporation with films which behave as incompressible two-dimensional fluids. They confirmed the previous observation that the evaporation resistance of a fatty acid film is independent of the film pressure when that pressure is above 10 dynes per centimeter and that this resistance is reproducible and increases with increasing chain length. For monomolecular layers consisting of molecules of different chain length but belonging to the same chemical group, the reciprocal of the evaporation resistance of the combined monolayer is the sum of reciprocals of the resistance of the individual components. For fatty alcohols, however, it was found that the resistance is dependent upon the film pressure—the greater the pressure, the higher the resistance.

During the First International Conference on Reservoir Evaporation, held in April 1956, W. W. Mansfield reviewed his previous work and reported on his most recent investigations (*13*). He had done considerable theoretical work on the quantity of hexadecanol necessary to compensate for various losses which could occur under field conditions. Among the losses considered were those resulting from solution in the water, evaporation, and expansion of the film by wave action. The thermal effects of a treatment were studied and it was shown that the temperature of the surface of the water would increase slightly, causing a slight decrease in the film effectiveness. It was found that the aging effects of long-chain alcohols were less for hexadecanol than any of the other materials tested and that the resistance of hexadecanol increased as the film pressure increased. Also studied were the effects of additives on the effectiveness of hexadecanol. It was found that small percentages of stearyl alcohol could increase the evaporation resistance of the film, the optimum concentration of the stearyl alcohol depending upon the water temperature and air velocity.

Early Field Studies

Considerable work has been carried out on the use of hexadecanol for control of reservoir evaporation by W. W. Mansfield in Australia. Field tests in Woomelang in 1953 indicated the need for further investigations of the technique of application. During the summers of 1954 and 1955 in southern Australia and during the dry season in northern Australia, several investigations were conducted (*14*) on open reservoirs and large tanks. Unfortunately, during the periods chosen, all of Australia experienced especially heavy and unseasonal rainfall. This complicated the water budget for these tests.

Hexadecanol in flake form was stored in floating, brass wire screen cages anchored in the reservoir to be treated. A monomolecular layer was

formed at the air-water-crystal interface and passed through the openings in the screen to the rest of the surface of the reservoir.

To evaluate the treatment, water storage and evaporation pan records for periods up to 15 years prior to treatment were examined. The loss from a given reservoir was then evaluated as a linear function of the seepage and evaporation. The periods of treatment ranged from 3 to 11 weeks, with results ranging from − 15 per cent to + 97 per cent reduction in evaporation. The most probable values were in the range 15 to 40 per cent. The treated reservoirs varied in size from 0.14 acre to 11 acres with dosages as high as 5 lb per acre. Although these results are encouraging, it is recognized that the field conditions would make precise evaluation extremely difficult. Later tests reported at the international conference indicated comparable results with reservoirs up to 22 acres.

Bureau of Reclamation Study

The Bureau of Reclamation's early investigations of the progress in evaporation suppression techniques consisted of a review of the literature and correspondence with every worker in this field. The correspondence survey and literature search showed that the laboratory and field studies up to that time indicated that monomolecular layer of fatty alcohols for reservoir evaporation reduction was promising. One of the better materials appeared to be hexadecanol. The survey also seemed to indicate that there were many phases of the study which needed further examination, particularly those involved in large-scale applications.

Fig. 1. Evaporation Pans Used in Screening Tests

Screening Tests

A program was established to investigate the evaporation-reducing abilities of various monomolecular layer-producing materials and duplex films (two-layer films consisting of a mono-

layer of a polar material on the bottom and a layer of mineral oil on top). These studies are carried out in 4-ft diameter standard US Weather Bureau Class A evaporation pans located outdoors. This installation is shown in Fig. 1. The size and location served to incorporate into the screening tests some of the factors present in field conditions.

Of the 125 materials tested, one —hexadecanol—showed outstanding properties. With hexadecanol flakes sprinkled on the pan at the rate of 60 lb per acre, a single treatment has been effective for more than 4 weeks, with a maximum efficiency of 64 per cent. Even with hexadecanol, however, the results vary considerably, depending upon the form and source of materials and upon ambient conditions. With hexadecanol, results have ranged from less than 10 per cent to over 60 per cent reduction of evaporation.

Pilot Studies

Three adjacent ponds, 33 × 10 ft, constructed with a watertight asphalt lining, were used to investigate further the efficiency of a surface treatment with hexadecanol under field conditions. In these studies, a broadcast type of application resulted in a 13 per cent reduction of evaporation, and a wire cage ("raft") type application resulted in a 16 per cent reduction. These values were observed notwithstanding the fact that crystals washed onto the liner reacted with the asphalt in the presence of sunlight and formed a chemical possibly capable of contaminating the monomolecular layer. The fact that the wire screening used for the floating cages had such small openings that it soon became clogged, undoubtedly reduced effectiveness too.

Toxicity Studies

Any chemical applied to a reservoir must not produce a condition toxic to humans, plants, or fishes. Full clearance within the limits of this particular application for the use of hexadecanol, from the standpoint of toxicity to humans, was received from the US Food and Drug Administration, Department of Health, Education, and Welfare.

Preliminary and limited toxicity studies were made by the Bureau of Reclamation to determine if the use of hexadecanol would represent a major hazard to fishlife, wildlife, fowl, or aquatic plants. Laboratory tests were made with several species of fish, aquatic microorganisms, emergent insects, ducks, and several species of aquatic plants. The effect on the transfer of oxygen and carbon dioxide across the surface was also evaluated.

The tests indicated that a surface treatment with hexadecanol would affect adversely only the emergent insects. It was recognized that although the results were encouraging, the investigations were not final or conclusive. More extensive studies are now underway at the University of Colorado.

Choice of Reservoir

The final evaluation of any method for large-scale evaporation reduction must be made on a large reservoir. The reservoir used, however, must have a water budget which is accurate enough to enable a precise determination of the evaporation.

It is not easy to find such a reservoir, as many elements of the water budget are difficult, if not impossible, to evaluate. An example of such an element is bank storage; the spongelike action of the bank by which large quantities

of water may be absorbed and later released.

The problem was faced in 1949, when a program was set up to evaluate and correlate factors affecting evaporation from large reservoirs and to test various instruments designed to measure these factors. After an exhaustive search, Lake Hefner in Oklahoma City was chosen. Lake Hefner, approximately 2,500 acres in surface area, is part of the Oklahoma City domestic water system. It has a small drainage area and a precise water budget.

The evaporation study was conducted jointly in 1950–51 by the Bureau of Reclamation, the USGS, and the Navy Department (*15, 16*).

With such properties and history, Lake Hefner is a natural choice for large-scale evaporation reduction experiments. As it is part of a public water supply, it was essential to determine if there would be any toxicity to humans or any deterioration of the water quality as a result of treatment with hexadecanol.

Kids Lake

The question of toxicity to humans, as mentioned previously, was placed before the US Food and Drug Administration. According to that organization, there appears to be no hazard to public health from the ingestion of small quantities of hexadecanol.

Because the effect upon water quality could not be fully predicted, a steering committee was formed to program, direct, and evaluate studies related to the proposed Lake Hefner program, including tests to evaluate the water quality question. The committee, composed of personnel from the Bureau of Reclamation, the Oklahoma City Water Department, the Oklahoma State Department of Health, the USPHS, and the USGS, decided that the water quality study would be conducted at Kids Lake, Oklahoma City, which is small (6 acres) and a former arm of Lake Hefner, formed by a dike across the arm.

The tests were made during July and August 1956, with more than 100 lb of hexadecanol scattered on the surface or in wire mesh rafts during the 2-month period. Since there was no outflow during this period, all of the material was retained at Kids Lake.

The results of the tests indicated that insofar as the criteria of water quality, including taste, odor, color, toxicity, and other chemical qualities are concerned, nothing was found in the Kids Lake study to preclude further consideration of Lake Hefner for large-scale evaporation reduction investigations (*17*).

Although the primary objective of the Kids Lake studies was to evaluate the effect on water quality, several other important observations were made. It was found that improved techniques of film application, maintenance, and detection should be developed, that the effect on many biological elements of the lake was either nil or favorable, and that the bacteria *Pseudomonas* and *Alcaligenes* increased in the presence of hexadecanol. The increase was from less than 10 to approximately 50 organisms per milliliter. This was not felt to be significant from a water quality point of view. A study of the biological oxidation of hexadecanol has been made by Ludzack and Ettinger (*18*).

Film Detection

The necessity for a reliable yet simple method for ascertaining actual establishment of a monomolecular film or layer was early recognized. There is need for a technique which will detect not only the presence of a film on the

water surface but one that will also indicate whether or not it is compressed sufficiently to exert an evaporation-reducing effect.

The degree of compression of monolayers on a water surface can be measured and expressed in dynes per centimeter. A monomolecular layer of hexadecanol on a water surface is only about 6×10^{-7} in. thick, and is invisible. It exhibits none of the interference patterns of color associated with much thicker multilayered nonmonomolecular oil films. The detection of the presence of an evaporation-reducing layer, therefore, constitutes one of the major problems in this endeavor. One of the developments of the Bureau of Reclamation's engineering laboratories was a mixture of hexadecanol with very finely divided talcum powder. When this mixture is dropped in a free water surface, a very rapid dispersion of the talcum powder can be seen as it is carried along by the hexadecanol which is forming a monomolecular layer (see cover photo, this issue). On the other hand, if dropped on a water surface already containing a monolayer, either a very slow movement takes place, or none at all. Although this test works very well under laboratory conditions with pure water subphase and hexadecanol as the only film-forming material, its results are difficult to interpret under field conditions. To overcome this difficulty a different technique was sought. Adams (*19*) had found that a mixture of light mineral oil and dodecyl alcohol would produce a duplex film of moderate film-spreading pressure. By varying the proportions of alcohol and oil, different spreading pressures could be obtained.

The Bureau has found in its studies (*20, 21*) that the relationship between the spreading pressure of the duplex film and the percentage of dodecyl alcohol is nearly logarithmic (Fig. 2). A set of these oils has been made for every 5 dynes per centimeter from 5 to 40 dynes per centimeter.

Field tests with these indicator oils have shown that it is quite easy to determine the film pressure of a surface layer to within 5 dynes per centimeter or less. It is felt that the presence and film pressure of a monomolecular layer can be easily and accurately determined with indicator oils: A drop of each oil is applied to the surface, beginning with the lowest spreading pressure and working upward. The film pressure lies between the spreading pressure of the first oil which spreads and that of the previously used oil (*22*).

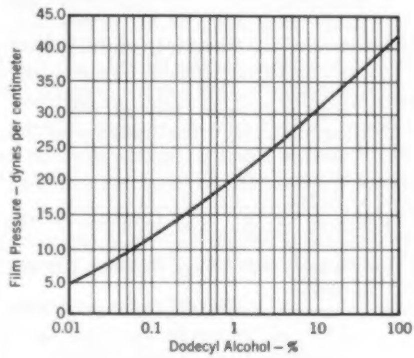

Fig. 2. Relation of Film Pressure on Water to Percentage of Dodecyl Alcohol in Mineral Oil

Application and Maintenance

Field studies are currently being conducted at Rattlesnake Reservoir, a 100-acre lake near Denver to develop a feasible technique for application and maintenance of monomolecular layer of hexadecanol on a large reservoir. Early results indicate that wind is a major factor in the process. When a satisfactory technique for film applica-

tion and maintenance of a large reservoir has been devised, the large-scale evaporation reduction evaluation tests at Lake Hefner will be initiated.

Acknowledgment

The authors wish to extend their appreciation particularly to Q. L. Florey, physicist, as well as to T. R. Bartley, T. Ensign, and K. B. Goral, all of the Bureau of Reclamation.

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Biological Oxidation of Hexadecanol Under Laboratory Conditions

F. J. Ludzack and M. B. Ettinger

A contribution to the Journal by F. J. Ludzack and M. B. Ettinger, both of the USPHS, Robert A. Taft San. Eng. Center, Cincinnati, Ohio.

THE resistance of hexadecanol to biological attrition has become important because this chemical shows promise for use in the reduction of evaporation from impounded water (*1–4*). It has been shown (*5, 6*) that a monomolecular film with specific physical characteristics can substantially reduce evaporation. Hexadecanol yields a film with the desired characteristics and appears to have other advantages for this use. Mansfield (*2*) proposed that hexadecanol be applied to large reservoirs by allowing a film of the chemical to spread from fixed rafts which also serve to renew the film continuously once it is formed.

Feasibility of the use of this material hinges upon many factors. Some of these include the ease and effectiveness of application, the amount of hexadecanol consumed as a result of mechanical or boundary losses, biological assimilation, and freedom from deleterious effects on water characteristics. The value of the water saved compared to the cost of saving it will eventually determine the practical value of the procedure.

The structure of hexadecanol ($C_{16}H_{33}OH$) suggests that it would readily be assimilated as a food by microorganisms. It is relatively insoluble, however, and this should limit its availability to the organisms in surface water.

Exploratory work on emulsified hexadecanol using the BOD test (*7*) resulted in oxidation of 30–60 per cent of the emulsified material in 5 days. This was definite evidence that microorganisms could metabolize hexadecanol, but not that such action would consume an oriented monolayer such as has been proposed for evaporation control.

Experimental Details

Carboys of 5-gal capacity were used as paired oxidation units, one of which served as a control. Each was charged with 8 liters of identical liquid substrate and laid on its side to increase air–water interface area (approximately 850 sq cm or 0.91 sq ft). Hexadecanol pellets were floated in the test unit. Estimated surface area of the pellets was 2–4 sq cm, giving more hexadecanol surface per unit of water surface than the minimum requirement proposed by Mansfield (*2*), which was 1 unit of hexadecanol surface per 1,000 units of water surface. The composition of substrates studied is shown in Table 1.

Inlet air for the units was passed through a series of three carbon dioxide scrubbers consisting of a dry soda lime tube and solutions of sodium hydroxide and barium hydroxide. The scrubbed

air was split into equal portions and introduced into each unit approximately 4 in. below the liquid surface, at the rate of approximately 90 bubbles per minute.

Exit air from each unit passed through three barium hydroxide scrubbers in series. The first of the three units was titrated daily and the carbon dioxide production was estimated from the difference between initial and final titrations of the alkali. A fresh absorber was inserted last in the line whenever one was removed for titration. The second and third gas washers were used in case carbon dioxide production exceeded the capacity of the first gas washer. The difference between the carbon dioxide recovered from the control unit and that from the hexadecanol unit was attributed to biochemical oxidation of the hexadecanol film or pellets.

Initial weight of hexadecanol * was obtained by direct weighing. During the oxidation period, material such as biological growth and silt became attached to the pellets. Hexadecanol was separated by extracting the total residual mass several times with warmed methyl alcohol, filtration of the extracting solvent, and evaporation in a tared flask; it was then weighed. The identity of the recovered fraction was confirmed, and the degree of purity estimated by means of its infrared absorption properties.

TABLE 1

Substrates Investigated

No.	Composition	Temperature °C
1	2 per cent settled domestic sewage in BOD dilution water	20
2	37.5 per cent substrate No. 1* by volume 62.5 per cent BOD dilution water	20
3	50 per cent Ohio River water 50 per cent BOD dilution water	20
4	Water obtained from a stock pond near San Antonio, Texas†	20
5	Substrate No. 4 with twice the mineral supplements suggested for BOD dilution water‡	22–25

* Substrate aerated with hexadecanol pellets for 20 days. Hexadecanol removed and stored an additional 28 days before test on Substrate No. 2.
† Test started approximately 10 days after sampling.
‡ Test started approximately 40 days after sampling.

Portions of the liquid substrate remaining were acidified and extracted with carbon tetrachloride to determine the type and amount of extractable components. This also was estimated on the basis of infrared absorption (*8*). Biological growth in both the control and hexadecanol units were qualitatively compared at the end of the oxidation period.

Light was excluded from all units except during manipulation to minimize algal growth. The stoichiometric ratio of hexadecanol to the carbon dioxide

* Catalog No. 2602, a product of Olin Mathieson Chemical Corp., Baltimore, Md.

produced by its complete oxidation was 1:2.91 by weight.

During experimental runs no agitation was provided other than the low-rate air flow. No attempt was made to evaluate the evaporation control qualities of the hexadecanol film.

Experimental Precautions

Air flow rate division between the control and hexadecanol units required frequent adjustment. Unless the rates compared within ± 20 per cent, the higher aeration rate invariably was detectable by a greater short-time transfer of carbon dioxide from the substrate. Fortunately, adjustment of the rate would restore the amount of carbon dioxide retained in the paired units to equivalent values within 1 to 2 days.

Some difficulty was experienced when baskets made of plastic screen with styrene foam floats were used to contain the hexadecanol during the test runs illustrated in Fig. 1 and 2. An empty basket was inserted in the control and the pellets were contained by the other. The two control curves suggest that some oxidizable material was leaching from the screen, float, or both. Use of the baskets was omitted after a small but measurable weight loss by the baskets during oxidation was noted. As the baskets in both units were comparable in material and mass, the relation between the differential carbon dioxide and hexadecanol assimilation should not have been affected.

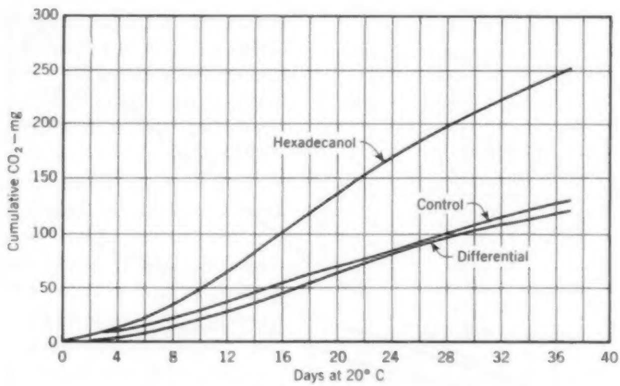

Fig. 1. Carbon Dioxide Production With Substrate No. 1

Substrate used in this test contained 2 per cent sewage. This shows the comparative CO_2 production between the solution containing hexadecanol and the control unit, along with the cumulative difference between the control and hexadecanol units attributable to hexadecanol decomposition (differential).

CO_2 Production

Curves showing the carbon dioxide produced in the control and hexadecanol units are presented for the various substrates in Fig. 1–5. Curves showing the cumulative differences attributable to hexadecanol decomposition are also presented on each chart.

In Fig. 1 (Substrate No. 1 in Table 1), accelerating production of carbon dioxide until an air failure occurred on the seventeenth day is shown. In the sewage-contaminated water the results indicate a relatively short life for a given monolayer. There also appeared to be some biological selection or acclimatization which increased the hexadecanol consumption rate with time during the observed interval.

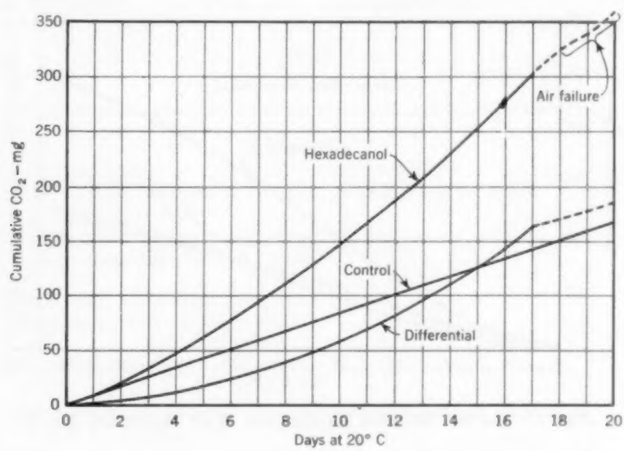

Fig. 2. Carbon Dioxide Production With Substrate No. 2

Substrate used in this test was stabilized sewage dilution from the hexadecanol solution represented in Fig. 1, following removal of hexadecanol and storage for 28 days.

In Fig. 2 (Substrate No. 2 in Table 1), a short lag followed by a slowly accelerating differential for about 2 weeks is shown. Following this the daily differential decreased in magnitude. Prior to stabilization a portion of this medium has demonstrated rapid assimilation of hexadecanol as Substrate No. 1. Storage apparently modified the growth-supporting characteristics of this substrate, so that the rate of assimilation of hexadecanol was reduced. There also was a further reduction in assimilation rate during the observation period.

With Ohio River water seed shown in Fig. 3 (Substrate No. 3 in Table 1), a definite lag in the carbon dioxide differential followed by a marked increase was indicated. The high daily differential failed to be maintained. By the end of the second week the daily differential was steadily decreasing, as if hexadecanol availability were seriously limited. On the twenty-first day, fresh pellets were added to the hexadecanol unit. Once more the daily differential increased for a short time (shown in Fig. 6). Apparently surface fouling of the pellets had some influence on the rate of assimilation of hexadecanol.

The data in Fig. 4 (Substrate No. 4 in Table 1) on the water obtained from a Texas pond presents a radically different pattern. Very little carbon dioxide was produced and the differential showed little hexadecanol assimilation. The chemical oxygen demand from di-

chromate (7) indicated that this water had a substantial oxygen demand (chemical oxygen demand approximately 70). A check of the nitrogen and phosphorus content indicated that both were limiting factors in biological activity. Following their addition on the twentieth day an increase in carbon dioxide production occurred but the assimilation of hexadecanol remained relatively low and variable.

In Fig. 5 (Substrate No. 5 in Table 1) results of tests made on the same water as that used in the Fig. 4 experiment are shown. Mineral supplements at double the concentrations recommended for BOD dilutions (7) were added before starting oxidation. Immediate production of carbon dioxide in both control and hexadecanol units occurred. For undetermined reasons No. 5 control lagged in the oxidation rate for a few days. The resulting hump in the differential curve could not be attributed solely to hexadecanol assimilation. After a few days the two units assumed more typical behavior. The higher temperature of oxidation resulted in somewhat more controlled carbon dioxide production than in the corresponding control charted in Fig. 4. The differential was also greater than in Fig. 4.

Nitrogen additions to the tests illustrated in Fig. 4 and 5 were apparently insufficient. No ammonia remained after oxidation was stopped. Organic nitrogen was lower than anticipated. Nitrous and nitric nitrogen were undetermined. Inability to obtain reproducible values on the BOD test of this water suggested inhibition beyond that attributable to a deficiency of nitrogen and phosphorus.

Pellet Surface Condition

In most oxidation tests the pellet surfaces were coated with filamentous material after a few days. The information charted in Fig. 6 was derived from that reported in Fig. 1, 2, and 3, but the curves represent the sum of 3-day carbon dioxide differentials arranged consecutively. With Substrate No. 1 (2 per cent sewage) accelerating assimilation of hexadecanol until air failure terminated the test was shown. This system showed relatively little accumulation of filamentous material on

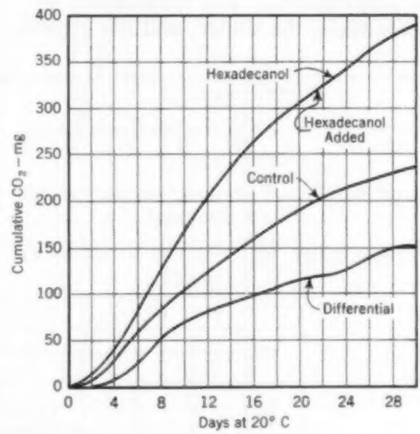

Fig. 3. Carbon Dioxide Production With Substrate No. 3

Substrate in this test was 50 per cent Ohio River water. To be noticed is the initial lag in the differential followed by a great increase in it. When the difference again decreased, fresh pellets were added.

pellet surfaces. With Substrate No. 2 (stabilized sewage) a gradual increase in differential followed by a falling portion of the curve was indicated. Filamentous material was quite noticeable on pellet surfaces during the later stages. The hexadecanol pellets used with Substrate No. 3 had more filamentous growth than those in any of the remaining oxidation units. A fairly rapid rise in the differential was followed by an equally rapid decrease.

After addition of new hexadecanol pellets on the twenty-first day, another increase was noted but not as great as before. The new pellets were quickly covered with the same type of growth as those added initially.

Biological Conditions

Both units of each substrate were checked for the type and variety of organisms present at the end of a series of observations. The hexadecanol pellet surface, the sludge, and the growth on the sides and surface of the container were examined. Quantitative measurements or species identifications were not attempted, thus the results report only the impressions obtained from direct microscopic examination by experienced observers.

Qualitatively, there was no evident difference between the types of organisms found in the control and the corresponding hexadecanol unit. Each unit contained a mixed population of microorganisms. There was a visually noticeable increase in relative numbers in the units containing hexadecanol as manifested by an increase in turbidity. Obvious growth was also apparent on and around the pellets and air inlet tube surfaces in hexadecanol units.

Substrate No. 1 showed a predominance of bacteria and protozoa. The remaining units contained primarily bacteria and fungi. The fungi were dominant in most units wherever they had an opportunity to become attached; bacteria were more generally dispersed. Substrate No. 3 showed an exceptionally large proportion of fungi with more biological material than any other substrate. A photomicrograph of growth found near the hexadecanol pellets used with Substrate No. 3 is shown in Fig. 7. The substrate from the Texas stock pond also produced a high proportion of fungi.

Fungal growth may be the cause of the irregular results charted in Fig. 6.

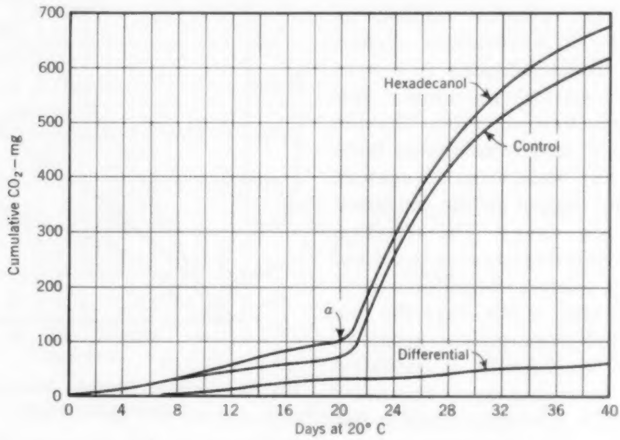

Fig. 4. Carbon Dioxide Production With Substrate No. 4

Substrate in this test was water from a Texas pond. On the twentieth day (Point a) *nitrogen, phosphorus, and potassium were added to both units.*

Substrate No. 1 did not show significant numbers of fungi but did support the highest rate of assimilation. In the later stages of oxidation, Substrates No. 2 and 3 showed decreased hexadecanol usage which coincides with a high degree of accumulation of filamentous material on the pellet surfaces. The pellet surface represented less than 1 per cent of the water surface area on which the monolayer could be formed; it is likely that the reduced hexadecanol assimilation was associated with limited availability because the mat of fungi reduced the surface coverage obtained.

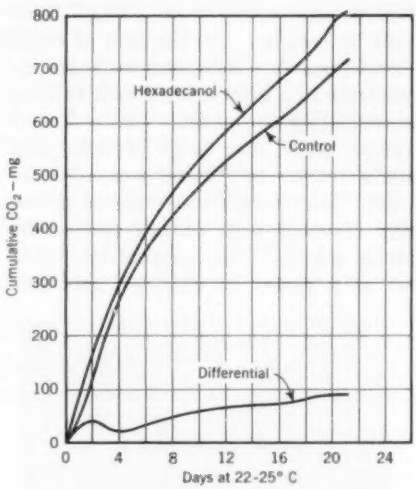

Fig. 5. Carbon Dioxide Production With Substrate No. 5

Substrate in this test was water from a Texas pond.

Weights and Balances

Table 2 shows hexadecanol weight loss during oxidation and an estimate of the fate of this material. Residues at the end of all observations (85–94 per cent of the applied material) were ample to maintain a continuous film assuming no change in spreading tendencies.

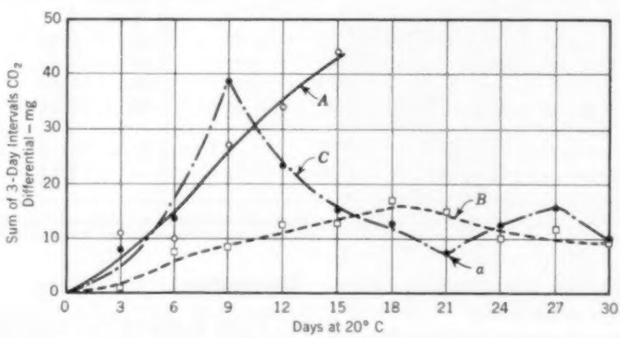

Fig. 6. Carbon Dioxide Differential in Three Substrates

Curve A *represents Substrate No. 1; Curve* B, *Substrate No. 2; and Curve* C, *Substrate No. 3. At Point* a *on Curve C, hexadecanol was added.*

Methyl alcohol extraction provided a simple and effective method of purification of residual hexadecanol, so that a reliable final weight was obtained. Traces of oxidation products were evident in the infrared curve of the extract, but there were no significant differences from the curve of fresh hexadecanol.

The amount of methyl alcohol insoluble material separated from the residual

hexadecanol varied from 1.3 to 7.5 per cent by weight. On the first of serial extractions this substance had the appearance of a gelatinous sheath entirely surrounding the pellet. Later the envelope broke into flaky particles that could readily be filtered from the extract. Microscopic observations generally revealed both fibrous and amorphous solids. This material tended to act as a binder between grouped pellets, so that they frequently were cemented into a solid mass.

TABLE 2

Data on Hexadecanol Oxidation

Recorded Observations	Substrate				
	1	2	3	4	5
Hexadecanol initial weight—*g*	0.5826	0.6050	0.6406*	0.4620	0.4828
Residual pellets, final weight—*g*†	0.5226	0.6017	0.5936	0.4410	0.4660
Hexadecanol, final weight—*g*	0.4995	0.5530	0.5855	0.4336	0.4422
Hexadecanol oxidized or lost—*g*	0.0831	0.0520	0.0551	0.0284	0.0406
Hexadecanol oxidized or lost—%	14.3	8.6	8.6	6.2	8.4
Pellet insoluble material—*g*	0.0231	0.0487	0.0081	0.0074	0.0238
Pellet insoluble material—%	4.4	7.5	1.3	1.7	5.0
Time interval—days	20	37	30	48	21
CO_2 equivalent of hexadecanol loss—*mg*	242	151	160	83	118
Differential CO_2 found—*mg*	185	123	155	67	92
Hexadecanol loss recovered as CO_2—%	77	81	97	81	78
Hexadecanol loss recovered as substrate extract (differential)—%	7	5	—	4	2
Other hexadecanol loss—%	16	14	3	15	20

* Test began with 0.4415 g hexadecanol pellets. On the twenty-first day, an additional 0.1991 g was added.
† Residual pellet weight included hexadecanol, silt, biological materials and other attached substances.

In all test substrates, carbon dioxide amounting to 77 per cent or more of that calculated from the hexadecanol consumption was obtained, demonstrating that the hexadecanol loss was primarily due to oxidation.

The percentage of extractable material in the substrate was low in all units. The results indicate little hexadecanol loss from the pellets by solution or mechanical attrition under test conditions. The difference in extractable material in the control and hexadecanol units represented 7 per cent or less of the weight loss of hexadecanol in the respective systems. Extracts of the substrate did not show a detectable amount of hexadecanol by infrared examination. Organic acids and esters were the major components. Otherwise unaccounted for material is believed to be represented largely by biological substance produced by metabolism of the hexadecanol.

Discussion

Table 3 shows the amount of hexadecanol loss obtained from the data on carbon dioxide production. Use of the carbon dioxide data for approximating the equivalent hexadecanol consumption results in lower than actual values since mechanical attrition, adsorption on solid surfaces, and synthesis of cell material were not included.

Lag periods sometimes developed so that little differential was obtained at the start of an experiment. The duration of the lag is given in a footnote to

Table 3, and the table itself reports results of behavior subsequent to the lag period. Each of the periods represents a measurable assimilation of hexadecanol ranging in weekly rate from 3.3 to 0.25 lb per acre.

The rate of destruction of hexadecanol observed in different substrates has been highly variable, and it is believed that further investigation would only tend to extend the range of behavior noted. Older, more stabilized substrates have supported a lower rate of hexadecanol assimilation. Seed organisms which use the chemical are extremely common.

TABLE 3

CO_2 Production in Term of Hexadecanol Loss

Period *consecutive week**	CO_2 Equivalent of Hexadecanol *lb per acre per week*				
	Substrate				
	1	2	3	4	5
1	1.05	0.87	2.06	0.77	—
2	2.90	1.25	1.58	0.59	1.04
3	3.33	1.01	0.79	0.27	0.96
4	—	0.80	1.07	1.05	—
5	—	0.74	—	0.26	—

* The estimated lag was 4 days for Substrate No. 2, 2 for Substrate No. 3, and 6 for Substrate No. 4.

Effects of algal growth in substrates on hexadecanol consumption have been carefully excluded from these experiments by light control to permit following metabolism of the hexadecanol on the basis of differential carbon dioxide production. In field use of hexadecanol, algal growth might well occur, and the production of carbon dioxide as the result of hexadecanol metabolism could promote such growth. It is believed that algal effects are best evaluated in field trials. Other and important field factors not contemplated include the effect of wind and wave action and the effect of soil in reservoir banks and bottoms.

This study has sought to limit itself to determining whether the hexadecanol is subject to biological assimilation, to get some idea of the variables involved, and to approximate the rates at which the chemical might be consumed. One factor of interest which has not been investigated is the effect of water temperature on the rate of alcohol as-

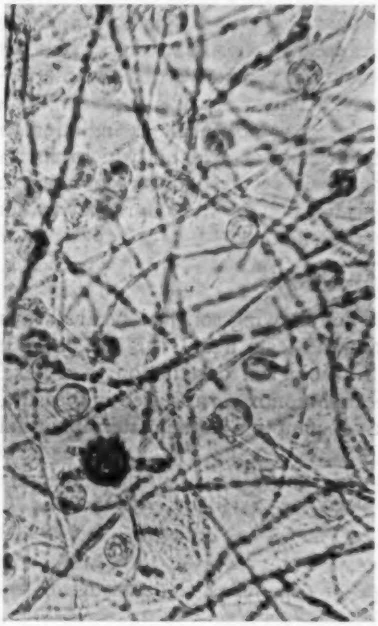

Fig. 7. Biological Growth on Hexadecanol Pellets

similation. Only speculation can be offered, but higher hexadecanol consumption would be expected at the higher temperatures of use.

In the laboratory studies, there have been indications that some types of growth may tend to encapsulate the hexadecanol source, preventing it from spreading, and thus conserve the chemical at the expense of maintaining the

desired film. The more vigorous mechanical agitation of field use might overcome this tendency; the data presented do not pretend to consider this question.

The results reported show that biological activity cannot be neglected in consideration of hexadecanol use. Loss of material, reduced spreading efficiency, and possible impairment of film efficiency by contamination of the monolayer (*5*) may be related to microbiological action. Realistic estimates of hexadecanol consumption and film efficiency must result from careful field study. This work has served only to single out biological assimilation of hexadecanol as a factor which has not previously received due recognition in consideration of films for evaporation suppression.

Conclusions

The following conclusions are drawn from the tests made:

1. Biological destruction of a hexadecanol monolayer resulted in measurable consumption of the material with all substrates tested. The amount is large enough so that it should be considered in the economics of use.

2. The rate of oxidation varied with the type of substrate, the variety and type of organisms, and the age of the oxidation system.

3. Formation of a mat of biological material containing a high proportion of fungi on the hexadecanol pellets affected the assimilation rate and may have affected film continuity.

4. There appeared to be relatively little buildup of extractable organic material in the substrate as a result of hexadecanol decomposition.

Acknowledgments

The authors are appreciative of the assistance of S. L. Chang, Wm. Bridge Cooke, and A. T. Romano in the examination of biological samples obtained from the oxidation units. R. N. Bloomhuff performed much of the experimental work and assisted in biological investigation. B. W. Beadle and the staff of the Southwest Regional Research Institute were very helpful in providing background data and samples of water for test purposes.

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Financing Water Works Improvements in Michigan

Panel Discussion

A panel discussion presented on Sep. 13, 1956, at the Michigan Section Meeting, Kalamazoo, Mich. It may be pointed out that a number of statements included in this discussion are not in strict accord with the Association's committee reports on water main extension policy. The ideas presented here will be valuable, however, in stimulating the thinking of Journal readers on a subject to which too much thought cannot be devoted.

Donald C. Egbert

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BIRMINGHAM, Mich., has grown in population from approximately 15,000 in 1950 to approximately 23,000 in 1956. The city experienced a rapid growth in the late 1920's and early 1930's, followed by a very moderate growth until 1949.

The source of water supply was, until recently, underground water-bearing formations. The cost of developing water resources was thus much less than in many other cities.

The early problems in the creation of water facilities were primarily a result of the lack of proper consulting engineering services. Since the early 1920's, however, the system has been carefully designed and a logical program of development has been followed. There have, therefore, been 30 years of development in conformity with an adequate plan.

The financing of a water system in a developing city requires careful planning and a willingness to establish rates which will form a sound basis for the issuance of revenue bonds. The development of the system should, for the most part, be financed by a combination of special assessments, general obligation bonds, and revenue bonds in order to secure equity between the current user and the owner of undeveloped property.

Financing has been made more difficult in Michigan as a result of the widespread defaults which occurred in the early 1930's. The legislature and the Municipal Finance Commission have created laws and regulations which currently provide for the issuance of sound securities by the municipalities. Revenue bonds, particularly for water facilities, are readily salable on the market, and they have, at times, been known to receive a higher rating than general-obligation bonds in the same municipality. This has been brought about by careful operation of the water facility and general acceptance of the water revenue bonds by the bond-buying public.

The problems involved in providing an adequate water supply for a develop-

ing city will thus be largely eliminated if: [1] an adequate plan to meet future needs for the community is developed; [2] competent advice relating to financing problems is secured; and [3] the utility is operated as such, resisting any efforts to divert revenue to uses other than those in the water department, and establishing rates sufficient to create adequate reserves and a revenue base to allow for future expansion.

A major problem involved in providing water to cities is that of meeting sprinkling load requirements. Property values in many communities are greatly dependent on the attractiveness of the area as a place of residence. The proper care of lawns and landscaped areas is a factor which helps create this desirable environment. The development of adequate storage facilities, which has been found to be the best method of meeting sprinkling loads, is thus of obvious importance to the citizen.

Although public officials are seldom critized for the overexpansion of water facilities, citizens are generally prompt to level criticism as soon as any inadequacy in the water supply is apparent. Public officials often have the ability to sell a sound program for development for any water system to the electorate, provided that the project is well conceived, the distribution of costs is equitable, and the electorate can be furnished accurate and clear answers to its questions.

Such a program might involve officials in some rather heated political battles, but experience indicates that, if the proper and complete facts are presented to the electorate, the program will receive its support.

John D. Harrison

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In the decade since World War II, nearly 10,000,000 new dwelling units have been built for Americans—providing more than 10,000,000 man-years of work directly on the job and millions more in factories, and adding approximately 100 billions to national production. These are immense figures which are almost too large to grasp. If the new units were placed end-to-end, each on a 60-ft lot, a band stretching across the United States more than 35 times would be formed.

The population has also greatly increased. In 1956, there were 4,100,000 live births, or more than 11,000 babies born every day of the year. In the 1940–50 decade, the United States population increased 14.5 per cent—13.9 per cent in the cities proper and almost 35 per cent in the suburban area. The so-called "rural rings" of the suburban areas grew much faster (approximately a 40-per cent increase) than the suburban areas themselves. Less than one-tenth of the 1940 population lived in the rural rings; by 1950, more than one-quarter lived there. The total population of the United States today is 166,000,000. It will be 193,000,000 by 1965 and 228,000,000 by 1975.

Detroit Growth

In the Detroit region of Michigan, building permits for 215,944 new residential units have been issued since 1950. This amounts to living space for 756,000 people, or more than enough room to house the 1950 population of Pittsburgh, and almost enough to house all the 1950 residents of San Francisco.

Employment in construction has, of course, also increased. In 1950, 47,000 persons were employed in construction work in the Detroit area; in 1955, 59,000 were employed.

In Detroit, Hamtramck, Highland Park, Ferndale, Dearborn, Ecorse, and River Rouge 15,756 new homes, or 36 per cent of the region's total of 43,975, were built in 1950. In 1955, however, only 2,463, or 6 per cent of the region's total of 39,953, were built. Less space available for residential construction in the cities proper has caused the drop in home building. Vacant lots no longer exist in cities as they once did. The future growth of the Detroit region will thus take place in the townships which today are regarded almost as rural areas.

In the 1950–55 period, the Detroit region population increase was larger than the total 1900 population of the same region (439,368). This growth will continue, especially after 1960 when the effects of the 1940's birth rate boom will be reflected in more marriages, babies, and demands for new homes. Accomodation for this increased population will have to be found in the suburbs and the rural townships—the so-called "cow pastures."

The Detroit Regional Planning Commission has predicted that Macomb County will increase from 280,000 in 1955 to 371,000 in 1960. Occupied dwelling units will rise from 79,000 in 1955 to 103,000 in 1960. In Oakland County, the population will increase from 542,000 in 1955 to 685,000 in 1960, and the number of occupied units will increase from 156,000 to 195,000 for the same period. In Wayne County, there will be an increase from 2,693,000 in 1955 to 2,904,000 in 1960, and the 767,000 occupied dwelling units in 1955 will have risen to 822,000 in 1960.

The regional planning commission also predicts that in the Detroit region as a whole, which includes Macomb, Oakland, and Wayne counties as well as five easterly townships in Washtenaw, the 1955 population of 3,564,000 will increase to 4,017,000 in 1960, and the number of occupied dwelling units from 1,000,000 to 1,136,000 units.

Effects of Growth

More people, of course, mean more water. In pioneer days, a newcomer's neighbors helped him "raise the ridge." They bent their backs to help him put his ridge pole in place for the roof that would shelter his family. Today, the economy of the community should be extended in the same manner, because it is traditionally American to help neighbors and to live in a cooperative rather than in a narrow and selfish spirit. Although new services should certainly be financed by the home owners and builders, any excess, such as a feeder or trunk line, should be paid for by the community at large. The very life of industry and commerce depends upon an adequate labor supply, which in turn needs homes in which to live. The use of taxes from industry and commerce for the building of water plants and trunk mains is thus as reasonable and logical as their use for the support of education. To charge the automobile industry a special fee for each car sold to pay for highway construction, police protection, and so on, would be as unreasonable as to charge the home builder or the new home buyer with the cost of an excessive share of water facilities. Taxes

on the property on which the new house is being built are, furthermore, frequently used for the support of the water system, even though no benefit accrued to the property while it was vacant.

The new home buyer, or his agent, the builder, should not be expected to pay a proportionate share of the capitalized value of the existing water facilities because:

1. The rate structure for water consumed should include maintenance and debt service costs, so that each new house owner participates in a fair proportion of these obligations as soon as he starts to receive any benefits—in this instance, water.

2. The financing of most municipal facilities is by long-term bond issues, and the facilities are usually depreciated so that no book value remains when the bonds are paid off. To charge for such facilities beyond the properly established rate structure would be to exact a payment from the new home owner for something already paid for, and for which full value has been received.

3. The enlargement of sources of supply and treatment plants and the strengthening of distribution systems benefit both new and old customers. Additional trunks and loops improve the grid, furnish increased pressure and better fire protection, and eliminate dead-end lines. Additional transmission lines and sources of supply are vital insurance when main breaks occur or major transmission repairs and maintenance must be carried out. The expenses incurred in strengthening systems, moreover, would be too great to be assumed by builders and new home owners. After all, it is the pressure of increasing population—not new home-building—which makes inevitable the expansion of the suburban community.

John E. Vogt

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With the increase in per capita consumption of water over the past few years, it has been well established that most water supply systems require expansion of the source, storage, or distribution, or a combination of all three. Although engineering solutions are generally forthcoming, financing is a more difficult matter.

Basic Financing Methods

The most familiar method of financing is the general-obligation bond, in which the full faith and credit of the municipality is pledged to retire the indebtedness. In Michigan villages and home rule cities, the amount of the bond issue is limited to 10 per cent of the assessed valuation of real and personal property. In fourth class cities, this limitation is 5 per cent of the assessed valuation. In all instances, the question must be voted on favorably by a two-thirds margin. One of the problems in using this means of financing is that a sizable water project can very easily exhaust a municipality's general-obligation bonding power, thereby leaving nothing for the many other needs of the community.

Another basic form of financing is by special assessment. When employing this method, owners of the land (usually 65 per cent) in the proposed district must petition the governmental unit to install the water works improvements; costs are then assessed proportionately against properties in the district. Various limitations are

imposed on the total amount which may be assessed annually, depending upon the unit of government and the number of years for which the assessment is to run. As a result of these limitations, special-assessment bond issues are not too salable on the bond market.

Another basic financing method is the use of the so-called revenue bond. These bonds are retired solely from revenues derived from operating the water system. No formal initiating action on the part of the people is required to sell a revenue issue. The governing body of the public corporation takes action on its own favorable vote to issue revenue bonds. Public corporations defined under the act which governs the sale of these bonds (*1*) include counties, cities, villages, townships, metropolitan districts, or any combination of these. There is a provision, however, that, if within 30 days following enactment of the bond ordinance, a petition opposed to it signed by 10 per cent of the registered electors is received, a referendum must be held on the question. The act does not limit the amount of bonds which can be sold, although, in practice, it is the amount which the city is able to market, or, in other words, the amount it is able to convince the bond-buying fraternity can be reasonably repaid. An additional control is the necessary approval of the ordinance by the Michigan Municipal Finance Commission, before bonds can be sold.

Township Financing

The uses and applications of the three basic methods of financing water projects in Michigan are varied. The original Township Improvement Act (*2*), which has been amended several times, authorizes townships and incorporated villages to purchase, construct, and extend water supply systems. Such a system operates under the control of a board of five commissioners who are residents of the water district and who are elected for staggered terms at the annual election. Financing of systems under this act is by the use of special assessments. The assessments may be spread over 40 years for initial purchase or construction of systems. For extensions to the system, however, there is a limit of 20 years.

Townships may also contract with cities or villages to have water furnished under an act (*3*) which provides merely for constructing water mains and buying the water. It requires a petition by 60 per cent of the recorded owners of the land. Financing is by a combination of general fund moneys and special assessments. Not more than 50 per cent of the cost of the distribution system can be paid out of the contingent fund of the township. If there are not sufficient moneys available, the amount may be raised by taxes in 1 year or spread for 10 years as a special assessment. The remaining 50 per cent is to be raised by special assessment.

Two other methods are available to townships desirous of entering the water business individually. Under a 1941 act (*4*), a township board may contract with any agency operating a water department to extend service into the township with continued operation either by the agency or the township. Payment for the cost of the system is through special assessment. Such assessment district may be created by a petition from the owners of only 51 per cent by area of the land in the district.

Assessments may be spread over 10 years.

Under another 1941 act (*5*), the township may also contract with another agency for water and construct its own distribution system upon petition of owners of 60 per cent of the land. Not more than 50 per cent of the cost comes out of the contingent fund of the township, and the remaining 50 per cent is raised by voluntary payment on the part of the property owners in the district. Failure to raise the needed money on voluntary subscription by a certain date invalidates the project.

A number of townships in Michigan are operating water supply systems under the provisions of one of the acts already mentioned.

Under the Metropolitan District Act (*6*), two or more cities, villages, or townships, may combine to install a water supply system. Such a district operates under a charter which provides for the administrative control of the district. The district may use several means for financing its operation, including an annual tax not to exceed 0.5 per cent of the assessed valuation of the property, the issuance of mortgage and revenue bonds, and the creation of a special-assessment district. A number of such districts have been formed along the Saginaw–Midland pipeline. The Beecher District north of Flint, Mich., has also been operating under this act.

County Financing

The act commonly referred to as the "county plan" (*7*) applies to all counties in the state and permits the board of supervisors to authorize the establishment of a water system between cities, villages, and townships within the county. Operating authority is vested in the county road commissioner, the county drain commissioner, or a committtee of three members from the board of supervisors. To obtain funds for such improvements, the county may issue its negotiable bonds secured by the full faith and credit of the contracting municipalities, or it may issue revenue bonds in accordance with the Revenue Bond Act (*1*). Provisions for the municipalities to raise funds to pay their pledged share of the cost of the facilities are many. They include: [1] a tax levied on all taxable property in the city, village, or township, which is not subject to any charter or statutory tax limitation; [2] special assessments levied on benefited property; [3] rates or charges to users and beneficiaries of the water system; [4] money returned by the state from state taxes, with the exception of certain earmarked moneys; and [5] any other fund which may be validly used for this purpose. Wayne County is operating its water supply system under the provisions of this act. The operating authority there is vested in the county road commissioner.

Water Authorities

In 1952, an act (*8*) was passed authorizing the formation of water authorities. This act authorizes the incorporation of any two or more cities, villages, or townships, or combination of them, to acquire, own, and operate a water supply system. For the purpose of acquiring, extending, and operating such a water supply system, self-liquidating revenue bonds may be issued in accordance with the Revenue Bond Act. The authority can then contract

for the sale of water to its constituent municipalities. Each city, village, or township, which is a part of the authority, is authorized to raise by tax, or pay from its general funds, moneys required by the terms of the contract for services rendered.

The Southeastern Oakland County Water Authority is organized under this act; the authority buys water from Detroit and distributes to Royal Oak, Birmingham, Berkley, Huntington Woods, Pleasant Ridge, Clawson, and the Township of Southfield. In other words, the authority acts as a distributor, buying the water wholesale, so to speak, and then distributing to its customers, the constituent municipalities. The authority assumes responsibility for the details of financing, thereby relieving each municipality of going through this matter individually, and it is necessary for the municipalities merely to establish their rate schedules to meet their obligations to the authority and cover their own costs of operation.

During the 1955 legislative session, another water authority act *(9)* broader in its scope, was passed, authorizing two or more counties and charter townships in addition to cities, villages, and townships, to incorporate as an authority for the purpose of acquiring, owning, improving, extending, and operating a water supply system. The act provides that bonds which are secured by the full faith and credit pledges of each constituent municipality may be issued by the authority. One of the important features of this act is the flexibility provided to the constituent municipalities for payment of their pledges. Five methods are authorized: [1] spreading the full amount on the tax roll with the provision that no limitation in any statute or charter shall prevent the levy and collection of this tax; [2] the levy of special assessments on property benefited; [3] revenues derived from operating the utility; [4] tax moneys returned from the state; and [5] any other funds which may be validly used for this purpose. To date, Oakland and Macomb counties, and Kent and Ottawa counties have organized to form authorities under this act.

Recent Action

The most recent method of financing water projects was passed at the 1956 session of the legislature *(10)* to broaden the powers and duties of the Water Resources Commission. The act authorizes the commission to establish water supply districts if they are needed and a petition is received from the people in the proposed district. Money for acquiring a water system is raised by the district through the issuance of revenue bonds. The contracting municipalities in turn raise money to pay the district for its services, using substantially the same five methods provided for in the water authority act of 1955.

There is currently some interest in private water companies that are furnishing water to municipalities. During the extra session of the 1956 legislature, a bill was passed authorizing townships to enter into contracts with private corporations to furnish water to the township. Such corporations may take water from any of the Great Lakes and from Lake St. Clair or waters connected or flowing into the same.

It is quite evident, even from this brief summary, that there are many legal means now available for financing needed water projects in Michigan.

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Water improvements are generally classified as being either of community-wide or local nature. Main transmission lines, storage and treatment facilities, and wells are improvements which benefit the whole community; distribution mains give only local benefits. Financing general or community-wide improvements has, in the past, given the most trouble, while it has usually been possible to finance distribution mains by special assessments, or, when new subdivisions were involved, to have the subdivider take action himself.

The many methods of financing water improvements can be reduced, from the financial standpoint, to two: [1] the issuance of revenue bonds; and [2] the issuance of general-obligation or special-assessment bonds.

Revenue Bonds

Revenue bonds can be issued legally by an individual municipality or a combination of municipalities who have joined in an authority. These bonds pledge as security the earnings from the water utility to be constructed or to be improved. Inasmuch as these bonds are payable solely from special earnings, it is necessary to establish a rate structure that will produce gross revenues sufficient to operate, maintain, and repair the utility, and to provide for 150 per cent of the annual debt service on the bonds. It can be seen that the feasibility of revenue financing is dependent upon knowing, with some degree of certainty, the number of customers actually existing and potentially available. The principal difficulty experienced with revenue financing is that there are too few customers currently available, so that the feasibility of this method is dependent upon future growth. The course of future growth, although ascertainable from general population trend studies, past building permits, and other data available, is still hazardous. This has resulted in substantially higher rates of interest on revenue bonds when growth is a factor. The amount of annual water charges necessary to meet fixed costs is also a limiting factor in the use of revenue bonds, except when a large industry is involved. If the annual water charge is in excess of $50 per service, a degree of difficulty will result in the financing.

Obligation and Assessment

Another method of financing water improvements is by pledging the general taxing power of the issuing municipality. This consists of general-obligation and special-assessment bonds, which pledge, for their payment, the faith and credit of the issuer. Special-assessment bonds which do not make this pledge are generally unmarketable.

A number of problems arise out of this type of financing: [1] statutory and charter debt limits restrict the amount of money that can be borrowed; [2] general-obligation bonds in cities and villages are limited to 10 per cent

of the valuation, and as city or village charters frequently limit bonding to a lower figure than this, the charter must be amended to receive full benefit of the provision; [3] the amount of special-assessment bonds which pledge the faith and credit of the issuer in any year is limited by the Municipal Finance Act (*1*) to 3 per cent of the valuation of the issuer, although bonds pledging up to 12 per cent of the valuation can be authorized if the electors of the issuers approve; and [4] community-wide improvements are made especially difficult by special-assessment procedures, because, in effect, a great many small parcels of land are pledged, and assessments in terms of benefits to the particular property involved are difficult to estimate. From the legal standpoint, therefore, special-assessment bonds have been found to be usable when restricted to local improvements such as distribution mains.

Combined Methods

The authority to issue general-obligation bonds is derived directly from a vote of the municipal electorate. Special-assessment bonds, however, may be issued without a vote of the electors; they may be issued upon initiation of the proceedings by petition or action of the city or village legislative body.

The two types of financing outlined have been used in various forms. They have been combined, for example, with the result that the maximum limitations of each have been utilized. A currently popular method is to use general-obligation bonds in defraying improvement costs, then placing the utility on a rate basis and using the rates to defray the principal and interest requirements on the general-obligation bonds. This usually permits financing at a lower rate of interest, as well as somewhat lower rates than would be required under a revenue plan because no security factor need be included in the rate structure. This type of financing has seen the most use in connection with court order sewer bond issues. Midland, Mich., and several small villages in the state have also used the method for water facilities improvements.

The basic problems in the financing of water improvements under the existing law are thus: [1] the general-obligation bonding power of many municipalities is not adequate to do the job and, furthermore, this power is often compromised by overlapping school debt, thus making it impossible, or at least difficult, to market general-obligation bonds; and [2] where revenue bonds are concerned, there are usually too few existing customers to provide adequate security at reasonable rates. The problems of water improvements exist in the present, but the tax base and the customers necessary to finance the improvement adequately will not be materialized for some years in the future. In many respects the problem is not unlike that recently faced by school districts in Michigan. The problem was resolved by passing a constitutional amendment which provided, in a sense, a limited state guaranty of school financing. This permitted the schools to build facilities which, on their present tax base, they could not afford and which were obviously needed to meet conditions that would probably exist in the near future.

Application of Methods

The impact of financing problems has differed according to the type of municipality involved. In the medium

or large city with an existing water utility, sufficient general-obligation bonding power and a sufficient number of customers usually permit general-obligation or revenue bond financing at low interest costs. In the small city or village, the same legal tools for financing exist as in the larger city, but the tax base and the number of customers are insufficient to provide adequate financing. By a combination of revenue and general-obligation financing, small-city problems can sometimes be solved. Often, however, it is simply impossible for the small city to acquire the necessary water improvements. This is particularly true in those communities which are making an initial installation of the water facilities. Townships, particularly those surrounding large cities, face the same problems as small cities and, in addition, have inadequate legal tools with which to accomplish their financing. Townships have suffered the most from water improvement difficulties. The previous author has pointed out some of the methods available to townships in overcoming their difficulties. A practical example is afforded by Wayne County, where the financing of water improvement has been accomplished under the "county plan" scheme (*2*). The county buys water from Detroit and transports it to the various township areas in the Detroit area. To a certain extent, this has removed the need for a community-wide improvement in the townships surrounding Detroit. A somewhat similar method could be used to service the townships surrounding all of the large cities in the state, either through the auspices of the county or through authorities formed under either one of the two acts which are presently available.

Recommendations

It is obvious that the existing situation calls for legislative changes to facilitate the financing of water improvements. The following are proposed, without reference to political expediency or desirability:

1. Specific legislation authorizing townships to issue general-obligation bonds for water purposes should be enacted, thus permitting, where possible, the acquisition and construction of desired facilities at reasonable costs and charges to the townships.

2. The signature requirements in the acts relating to installation of water mains by special assessments in townships should be simplified.

3. General-obligation water bonds should be authorized to be issued for a 40-year period. Although some difficulty has been experienced in the sale of 40-year bonds, this provision, at least, would permit additional financing.

4. The Revenue Bond Act should be amended to permit the imposition of charges on abutting property not connected to the water utility. This raises the practical problem that such charges would be no better than special assessment, which is not deemed adequate security for a bond issue. Legally, the imposition of such charges would have to be on the theory of benefits derived. This would mean that it would not be unlike a special assessment, so that it might become necessary, under several court interpretations, to proceed with proper special-assessment procedures.

5. The Municipal Finance Act and the Revenue Bond Act (*3*) should be amended to extend the time in which the first bonds have to mature and to liberalize the ratio of prior maturities to subsequent maturities. This would

permit the borrowing of money without the heavy repayment of principal obligations in the early years and would also permit anticipation of growth beyond the 5-year period now required under the Revenue Bond Act and the 3-year period now required under the Municipal Finance Act.

6. A state guaranty for payment of bonds issued for water purposes should be provided, which might perhaps be not unlike that now permitted for school purposes. This, of course, would permit financing without reference to existing conditions and ability, and would permit taking full advantage of potential growth factors. Such a guaranty would probably involve a constitutional amendment.

7. The so-called "15 mill amendment"—the Michigan constitutional provision limiting a township's taxing power—has the practical effect of limiting any guaranty for payment of bonds made by townships and should be repealed. The repeal would render quite feasible all township special-assessment bonds and would make township general-obligation bonds much more attractive.

8. Federal or state grants-in-aid should sometimes be provided, thus reducing the amounts to be raised in the usual manner and permitting larger projects than might otherwise be feasible. Although this might eliminate some bonding the author feels that it would, in fact, provide for more bond issues by enlarging the number of potenial participants.

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Applications of Submersible Pumps

James E. Barry

A paper presented on Mar. 21, 1957, at the Illinois Section Meeting, Chicago, Ill., by James E. Barry, Supt., Water Dept., Aurora, Ill.

ALTHOUGH the largest application of the submersible pump is in the deep-well field, it is not necessarily correct to make the two synonymous, as many do.

Some may feel that the submersible pump is a type of equipment comparatively new and others may have only a vague realization of what it is. No one, probably, is aware that a pump and electric motor combination that would work beneath water was successfully designed as early as 1908 and, more important, that wide usage of such a machine was achieved during the first World War. It is from these early beginnings—as early as those of the conventional deep-well turbine development—that today's modern range (generally $\frac{1}{3}$–450 hp) of submersible equipment came.

Early Design

It was only logical to the early designers that the most efficient arrangement for a pump and driver was as close together as possible. On just such a design were the first patents taken out in 1908 on a motor that would operate when completely submerged. The windings of this motor were sealed off from the water by insulation on the windings themselves. The motor was large and bulky and left a great deal to be desired from a design standpoint. It was, however, an important milestone, marking the beginning of an era.

Little was done in the field until the 1920's, when two new designs were patented—an oil-filled motor and a wet, or water-filled, one. In the water-filled motor, the windings were sealed off from the well water by a stainless-steel sleeve between the rotor and stator. These basic designs are still used.

How rapidly the submersible pump is being accepted, can be seen from the rise in pump sales from approximately 100 units in 1947 to over 60,000 units in 1956. Although the majority of the units sold were of the small, domestic type the sales figures are indicative of the acceptance of the submersible idea. This acceptance of small units has had a great influence on acceptance of the larger counterparts. They have proved the value of the pump, acquainting all with the soundness, from a practical standpoint, of the idea.

Deep-Well Service

Almost every town or community today has at least one problem in common with all others—acquiring an adequate and dependable water supply for increased populations, new appliances, and changed modes of living. The search for adequate and dependable water supplies has led to ever-increasing pump settings. With the conventional line shaft pump this has meant extending line shafts to greater lengths. This has brought about horsepower losses and increased mechanical problems.

With the submersible pump water can be pumped from any depth, efficiently and economically. Today's submersibles are pumping water from depths as great as 1,450 ft. There is no alignment problem and, because there is no long shaft, operation is quiet and smooth in all cases. This is particularly true in the case of the crooked well. As long as there is sufficient room to install the pump, such a well need not be abandoned.

Thus far, discussion has been restricted to the deeper settings. Submersibles, however, are equally advantageous in the shallower settings. The already mentioned widening search for adequate and dependable water supplies has led to the location of wells in residential neighborhoods. When the conventional pump is used, two major problems arise: first, and most important, is that of noise created by the vertical motor and second is that of constructing a pumphouse—usually more costly than both well and pump—that will blend with surroundings.

With the submersible pump, there is no noise problem. A 300-hp submersible motor and pump running at full capacity make no more noise than a kitten crossing a living room carpet, and the pumphouse cost is almost completely eliminated.

The search for adequate and dependable water supplies has led to development of wells on or near a river bank on the flood plain. There, great precaution must be taken to protect the well and the vertical motor from flood waters. With the submersible pump there is no fear of motor damage from flood. The problem of surface water contamination of the well by flood waters is completely eliminated through a watertight seal that can be used in conjunction with the pump. On the conventional pump the rotating shaft through a stuffing box offers a route by which contamination may enter.

River Intake Work

The floodproof feature has led, naturally, to the use of these pumps in river intake work. Not only is the expensive structure commonly associated with river intake stations eliminated, but maintenance costs from pump bearing wear have been reduced or virtually eliminated. This bearing wear is brought about by silty river water that is present in virtually every surface stream. Today, submersible river intake pumps are available that have no pump bearings exposed to the pump liquid. All bearings are contained within the motor where they operate under controlled conditions. It can be readily seen how pump life can be increased through such an arrangement.

Booster Service

Submersible pumps are used, too, in booster service. For this purpose a conventional submersible pump and motor are set in a receiver or barrel. Existing main pressures are discharged into this completely sealed barrel where the pump picks up the main pressure and discharges at the desired increased pressures.

It is the accepted practice to build sumps and elaborate buildings to house the conventional booster station. Land has to be purchased and, often, expensively maintained. The submersible booster station occupies very little space and may be located beneath the street, sidewalk, or any other city-owned property. Savings in construction and land costs could be quite large.

A further advantage can be derived by making the station completely automatic, requiring no attendants and, most important, capable of being situated wherever the booster is required.

Elimination of routine maintenance on any application is another major advantage. This applies whether the application is booster service, deep-well service, or river intake work. With the conventional pump, bearings have to be lubricated, packing adjusted, and other routine checks made. The submersible eliminates this responsibility, which means lower operating costs to the municipality or owners of the equipment. Such savings in operating costs are not idle talk.

Selection

It should be remembered that despite all its advantages the submersible is not a panacea for all pumping applications. It should be selected with care. What is expected of the unit and the conditions under which it will be operating should both be kept in mind. A contractor, engineer, or manufacturer who has had experience in the field should be consulted and all data should be given to him. His experience can help in getting the proper equipment for years of trouble-free life.

It is a proved fact that over 90 per cent of the troubles encountered with submersibles are a result of outside difficulties. It should be remembered that all submersibles are good and acceptable pieces of equipment; their manufacturers could not stay in business if they were not.

The advantages of submersibles are many and their uses wide and varied. It is not the new way, but the modern way of pumping water in ever-growing communities. There is a submersible pump designed to fit virtually every pumping need.

The Determination of Free and Combined Chlorine in Water by the Use of Diethyl-p-phenylene Diamine

Arthur T. Palin

A contribution to the Journal by Arthur T. Palin, Chief Chemist, Newcastle & Gateshead Water Company, Newcastle upon Tyne, England.

FOLLOWING the development of analytical methods for determining residual chlorine by the use of neutral orthotolidine (*1*), the earlier dimethyl-*p*-phenylene diamine (*p*-aminodimethylaniline) procedure (*2*) has now been brought up-to-date. Certain improvements have been incorporated, including a simple procedure for the further analysis of the combined chlorine fraction.

In preference to the dimethyl compound the corresponding diethyl-*p*-phenylene diamine (DPD) has been adopted because it gives sharper free and combined chlorine differentiation. When used in its oxalate form, reasonably stable solutions can be prepared.

With this indicator, free chlorine reacts instantly to give a red color. The subsequent addition of a small amount of potassium iodide (KI) immediately causes monochloramine to produce some color. Further addition of KI (enough to provide considerable excess) evokes a rapid response from dichloramine without any need for pH depression. Nitrogen trichloride (NCl_3), when present, appears in the dichloramine fraction. A simple change in the order of adding the reagents, however, can bring it into the first fraction with the free chlorine. In this way, an estimation of the NCl_3 concentration can be made. The indicator cannot be used in its oxalate form if it is desired to use the acid-alkali technique of the neutral orthotolidine method in determining dichloramine. This is because of the color-reducing effect of the oxalate at low pH.

Stability of Indicator Solution

A difficulty associated with the use of solutions of these phenylene diamine derivatives is their tendency to become discolored on standing. Such deterioration is accompanied by a loss of sensitivity in the color reaction with chlorine. The color mixture, itself, then also tends to show fading within a few minutes.

In a method for the determination of phenols, Nusbaum (*3*) made use of the oxalate salt of DPD which does not readily oxidize or become discolored when exposed to air, and reported that a 0.1 per cent solution of the amine salt (as free base) in a 1 per cent solution of sulfuric acid remained stable indefinitely. For the purpose of the present determination method, this strength of acid in the reagent would be inconvenient, and it has been necessary to use a concentration of 0.2 per cent without, it appears, seriously af-

fecting the keeping quality of the solution. It is recommended, nevertheless, that the indicator solution not be kept after it has become noticeably discolored. Storage in amber bottles is essential.

That errors in the chlorine determinations are related to the discoloration of the reagent solution is borne out by the results shown in Table 1.

Monochloramine and Dichloramine

The monochloramine breakthrough into Fraction 1 (free chlorine) is negligible if readings are taken reasonably quickly. A sample containing 3 ppm of monochloramine, for example, at 18°C gave apparent free-chlorine readings of 0.04 and 0.08 ppm after standing 0.5 and 1 min respectively.

TABLE 1

Effect of Deterioration of Indicator Solution on Determination of Free Chlorine in Water†*

Optical Density per cm ($\times 10^{3}$) of Indicator Solution to Green Light	Indicated Free Chlorine—*ppm*
0.3	3.0
0.9	3.0
1.3	3.0
2.8	2.8
3.6	2.7
6.3	2.6
7.4	2.6
11.0	2.2

* Solution used was 0.1 per cent DPD oxalate in 0.2 per cent (by volume) sulfuric acid solution.
† Distilled water containing 3 ppm chlorine.

The time required for the dichloramine color to develop fully at the pH of the test depends on the iodide concentration and on the temperature. The addition of 1 g of KI for every 100 ml of sample and a waiting period of 2 min have been found generally satisfactory. At higher temperatures such as might be found in swimming pool water, the period could be safely reduced to 1 min.

With these procedures it has been established by many check determinations that the results obtained using the new indicator—photometrically, or volumetrically with ferrous ammonium sulfate (FAS)—are in agreement with those obtained by the standard neutral orthotolidine method.

Nitrogen Trichloride

In the neutral orthotolidine method, NCl_3 displays color with free chlorine in Fraction 1 and this color corresponds to half the NCl_3 concentration in terms of available chlorine.

When DPD is used as the indicator, NCl_3 does not respond in Fraction 1 so that any color produced there is due entirely to free chlorine. The NCl_3 then appears in Fraction 3 (dichloramine), which is an advantage, because it means that undesirable chlorine compounds (from the taste and odor viewpoint) are brought together in the same fraction. Thus, in controlling water chlorination, whatever the process used, the aim should be to keep Fraction 3 compounds at as low a concentration as possible.

Some part of the NCl_3 can be obtained in Fraction 1 if it is fixed with the neutral orthotolidine indicator before adding the DPD. The red tint finally obtained is, however, somewhat modified.

Another method of shifting NCl_3 to Fraction 1 is by addition of KI to the reagents before adding the sample. Using this as the basis, a procedure has been devised for the separate estimation of NCl_3. When KI is used in this way it has been noted that a further proportion of NCl_3 continues to appear in Fraction 3. The total of the different fractions then approaches the figure for total available chlorine, but there still remains a deficiency resulting from an incomplete reaction with NCl_3 in

Fraction 3. Of the total NCl_3 present, only approximately 90 per cent responds when KI is used in this way. There is a notable similarity in this response to the results of Dowell and Bray (*4*) which indicated only 91 per cent response in the iodometric determination of NCl_3.

Because NCl_3 and monochloramine are not usually found together, it would not, as a general rule, be necessary to make allowance for the fact that the use of KI in the way proposed would also cause monochloramine to appear with free chlorine and NCl_3.

It may also be noted, in connection with the determination of NCl_3, that the fact that DPD does not respond to NCl_3 in Fraction 1 (KI being absent), whereas neutral orthotolidine does, provides a very simple alternative to the present techniques for NCl_3 determination in the FAS method.

In Fraction 1 of the FAS method, both chlorine and NCl_3 readings are given by neutral orthotolidine indicator, whereas DPD gives only free chlorine. Thus, having determined the three available chlorine fractions by the FAS method, the Fraction 1 determination can be repeated with DPD indicator substituted for neutral orthotolidine. The difference in the Fraction 1 readings when multiplied by two gives the NCl_3 concentration.

With the procedures suggested, attempts have been made to place the behavior of NCl_3 on a quantitative basis, and a procedure along these lines has given reliable results.

TABLE 2

*Sample Quantitative Calculation in Presence of Nitrogen Trichloride**

Method	Fraction 1	Fraction 3
1†	2.99	0.50
2‡	0.83	2.19
3§	2.93	—
	Procedure A	
Free Chlorine	NCl_3	Dichloramine
0.83	$2(2.99-0.83)=4.32$	0.50
	Procedure B	
0.83	$2(2.93-0.83)=4.20$	$2.19-(0.4\times4.20)=0.51$

* All figures in ppm available chlorine.
† Neutral orthotolidine titration with FAS.
‡ DPD method with FAS titration or, alternatively, a photometric procedure.
§ The same procedure as in the DPD method above, except that KI is added to the reagents before the sample.

In the sample calculation shown in Table 2, under Procedure A, the Fraction 1 (Method 2) reading, which gives only free chlorine, is used to subdivide the Fraction 1 (Method 1) reading into free chlorine and NCl_3. In Procedure B the Fraction 1 (Method 3) reading, less the Fraction 1 (Method 2) reading gives a figure for NCl_3 which, when multiplied by two, gives the total NCl_3 concentration. The total NCl_3 figure when multiplied by 0.4 is then subtracted from the Fraction 3 (Method 2) reading to get dichloramine. The

reason for this step is that, as already noted, a 40 per cent proportion of NCl_3 present appears with dichloramine.

Comparative results for samples of water specially prepared in the laboratory to contain high NCl_3 concentrations are given in Table 3. It is, of course, unlikely that the determination of such high concentrations would normally be required and, since the use of DPD as indicator has now separated NCl_3 from free chlorine, there is, perhaps, less need in practice for its determination as a separate fraction. In the experimental results shown, Fraction 2 (monochloramine) readings are not recorded because this fraction was absent or nearly absent in all cases. The procedures shown in Table 2 were used for full differential analysis in the presence of NCl_3.

TABLE 3

*Comparative Results With Laboratory Samples Having High NCl_3 Concentrations**

Procedure	Free Chlorine	NCl_3	Dichloramine	Total
A	2.8	6.3	0.4	9.5
B	2.8	6.3	0.4	9.5
A	2.8	3.7	0.1	6.6
B	2.8	3.4	0.1	6.3
A	0.7	2.9	2.1	5.7
B	0.7	2.6	2.2	5.5
A	0.8	4.3	0.5	5.6
B	0.8	4.2	0.5	5.5
A	1.7	2.3	0.1	4.1
B	1.7	2.0	0.3	4.0
A	1.6	1.5	0.9	4.0
B	1.6	1.6	0.9	4.1
A	1.5	2.2	0.2	3.9
B	1.5	2.2	0.2	3.9
A	1.2	1.6	0.8	3.6
B	1.2	1.9	0.8	3.9

* All figures in ppm available chlorine.

Interfering Substances

Oxidized manganese gives a color in Fraction 1 and has to be corrected for by the procedure given. In the presence of the amount of KI now used for activating Fraction 3, both copper and nitrite, if present in large enough amounts, interfere by giving red colors with the indicator. If the copper content of the water is within the US Public Health Service Drinking Water Standard of 3 ppm, no significant error is introduced. As for nitrite-nitrogen, concentrations up to at least 5 ppm were found not to interfere.

Dissolved oxygen gives a faint color on standing, and the effect of increasing temperature is to increase the error, which can be practically eliminated by reducing the pH of the color mixture. The risk of causing monochloramine to break through into Fraction 1 sets a lower limit for the pH. The buffer solution adopted is considered to represent a satisfactory compromise, and dissolved oxygen errors are reduced to insignificance. With a fully saturated water at a temperature of 18°C, for instance, the error amounted to no more than 0.01 ppm (in terms of free chlorine) in 5 min; with only 2 min standing, the error was decidedly less. The presence of KI in the color mixture was found not to increase the dissolved oxygen error.

Fading of Colors

The question of fading becomes important if, as now proposed, a waiting period is to be introduced in the dichloramine determination. If, however, the precaution of discarding indicator solutions which have become appreciably discolored is adopted then

fading of color in the DPD test is not a problem.

It remains advantageous, however, if unusually high water temperatures are encountered, to reduce the waiting period to 1 min in the dichloramine determination.

Some results to show the extent of fading in terms of apparent chlorine readings are shown in Table 4. A sample containing free chlorine in distilled water was used and the readings were taken photometrically using a green filter.

FAS solution, determinations may be carried out by titration to colorless endpoints.

Preparation of Standard Colors

A standard permanganate solution may be used with the DPD indicator for preparing standard colors or for matching a given color by gradual addition, with mixing, to a control tube in a duplication procedure. These permanganate-produced colors can also be titrated by FAS solution, providing a method of calibrating the latter solution. The use of KI with permanganate for producing standard colors is not permissible.

TABLE 4

Apparent Chlorine Readings Using Indicator Solutions of Different Ages

Temperature °C	Indicator Solution	Chlorine Readings—*ppm*				
		At Start of Test	1 min. After Start	2 min. After Start	4 min. After Start	6 min. After Start
14	A*	1.95	1.95	1.95	1.95	1.95
14	B†	1.74	1.72	1.69	1.60	1.51
23	A	1.95	1.95	1.95	1.94	1.93
23	B	1.71	1.67	1.53	1.42	1.33

* Four days old.
† Ninety-five days old.

Continued addition of chlorine to a solution containing a fixed amount of DPD will eventually bleach the color first formed. It is thus important that the amount of indicator used provide an excess for the whole range of chlorine concentrations to be covered. Although the amount used is adequate for more than 4 ppm of available chlorine, restricting the upper limit of chlorine to that figure should provide an adequate safeguard against any errors due to insufficiency of indicator. For higher concentrations it is suggested that less of the sample be taken.

The red colors produced in the DPD method are decolorized instantaneously by FAS. Thus, by using the standard

As an alternative to permanganate, a standard iodine solution may be used, being prepared as required by dilution of a stock $10N$ solution.

Spectrophotometric analyses showed no differences in the colors produced by permanganate, iodine and chlorine.

Volumetric Method

The reagents used in the volumetric method and their means of preparation are:

1. A solution of 0.1 per cent DPD oxalate, prepared by dissolving 0.1 g

DPD oxalate * in chlorine-free distilled water to which 2 ml of 10 per cent (by volume) sulfuric acid has been added (Make up to 100 ml and store in an amber bottle. The solution should keep satisfactorily for 1 month but must not be used if any discoloration is evident.)

2. A buffer solution containing 2 g sodium phosphate, 6 g potassium phosphate, and 10 g sodium hexametaphosphate per 100 ml of solution in distilled water (To prevent mold growths, 20 ppm mercuric chloride may be added.)

3. KI crystals

4. The standard FAS solution (1 ml ≡ 0.1 mg chlorine), prepared by dissolving 1.106 g FAS in freshly boiled and cooled distilled water to which 1 ml of 25 per cent (by volume) sulfuric acid has been added (Make up to 1,000 ml.).

Continuing experiments have resulted in some proposed revisions of Reagents 1 and 2 described above. With the revisions incorporated, the reagents would be prepared as follows:

1. Dissolve 0.1 g DPD oxalate or 0.15 g DPD sulfate ($NH_2 \cdot C_6H_4 \cdot N(C_2H_5)_2 \cdot H_2SO_4 \cdot 5H_2O$) in chlorine-free distilled water to which 2 ml of 10 per cent (by volume) sulfuric acid and 2.5 ml of 0.8 per cent disodium ethylenediamine tetraacetate dihydrate (EDTA) have been added. Make up to 100 ml, store in an amber bottle, and discard when discolored.

2. Dissolve 2.4 g sodium phosphate and 4.6 g potassium phosphate in distilled water. Add 10 ml 0.8 per cent EDTA solution and make up to 100 ml. Add 20 ppm mercuric chloride if necessary, for prevention of mold growth.

The EDTA which replaces the sequestering agent sodium hexametaphosphate in revised Reagent 2 will overcome interference by copper in concentrations of up to approximately 10 ppm. In connection with the use of sequestering agents in this way, it may be noted that the virtually complete suppression of dissolved oxygen errors is probably due in no small measure to prevention of trace metal catalysis.

The stability of the DPD solution is considerably enhanced by incorporating EDTA because this, it has been found, also retards deterioration by oxidation.

The sulfate of DPD * may be used as an alternative to the oxalate and, being of more precise composition, is, perhaps, to be preferred.

The procedure for determining free and combined chlorine by the volumetric method is as follows:

Free chlorine. To 5 ml each of Reagents 1 and 2 above, add 100 ml of sample and titrate with FAS solution.

Monochloramine. Add one small crystal of KI,† mix, and continue titration.

Dichloramine. Add several crystals (about 1 g) of KI and mix rapidly to dissolve. Let stand 2 min and then

* Product used by author is marketed as Compound 7102 by Eastman Kodak Co., Rochester, N.Y.

* Now available as a pale-cream crystalline powder from British Drug Houses, Ltd., England.

† The optimum amount of KI for monochloramine activation is 2–5 mg per 100-ml sample. In practice, the amount is not usually critical and the addition of one small crystal would normally be satisfactory. It is rather more critical when the concentration of dichloramine is relatively high, as too much KI at the second stage will tend to cause dichloramine to break through into the monochloramine fraction. For more accurate dispensing in such circumstances, a solution of KI should be used, adding 1 ml of 0.5 per cent solution per 100-ml sample.

continue titration. Any drift-back of color at the endpoint when titrating relatively large amounts of dichloramine indicates a slightly incomplete reaction. In such cases allow a further 2-min period of standing.

If the total concentration of available chlorine is likely to exceed 4 ppm, take a smaller quantity of sample. When diluting, the requisite amount of chlorine-free distilled water is added first and mixed with Reagents 1 and 2 before adding the sample.

NCl_3 may, in the absence of free chlorine, also be taken as absent. When present, as its distinct odor will indicate, it will normally appear with dichloramine. An estimate of its concentration may be obtained by adding samples and reagents in the following order: Reagent 2, small crystal KI, sample, Reagent 1. From the reading thus obtained, deduct the normal Fraction 1 (and Fraction 2 readings, if any) and multiply by two. This gives NCl_3, the value of which is multiplied by 0.4 and then subtracted from the normal Friction 3 reading to determine chloramine. The total available chlorine figure is the sum of the various constituents. (In the presence of relatively high dichloramine concentrations, use a KI solution as described in the footnote.)

When the DPD sulfate is used in place of the oxalate, the acid-alkali technique for dichloramine activation may be used. The excess KI method, however, obviously remains simpler and, if it is desired to reduce consumption of KI where many tests are being performed, the use of 50-ml portions of the sample with half quantities of the reagents and half-strength FAS solution is permissible.

No way has been found of combining Reagents 1 and 2 in a single solution of adequate stability. Suitable mixtures in tablet form have, however, been successfully prepared and permanent glass standards are being developed * for use with tablets in a simple test.

For the determination of total available chlorine, only one tablet in which KI would be incorporated with the indicator would be required. For the determination of free and combined chlorine, two different tablets would be used, the second containing the KI. By introducing a third tablet, all three fractions are obtained by the usual procedure and, where required, a simple supplementary test determines the NCl_3.

When reagents are used together in solid mixture, experience has shown the addition of powdered sodium hexametaphosphate leads to a reduction in color intensity not encountered when the chemical is applied in solution form. The reason for this is not clear, but the fact remains that in adding reagents as a solid mixture the sequestering agent must be EDTA. In the simple one-tablet test for total available chlorine, where excess KI is used from the start, copper may give a color until sufficient EDTA has dissolved to produce its chelation. Such colors are, however, transitory and disappear within the 2-minute period of the test. With the differential tests, copper is, of course, chelated before any KI is added and cannot then produce color.

Colorimetric Method

The procedure for free- and combined-chlorine determination by the colorimetric method † is as follows:

* Tintometer Ltd., Salisbury, England, will produce the permanent glass standards.

† In connection with commercial development of colorimetric apparatus and procedures, it should be pointed out that the process referred to in this article is the subject of a British patent application.

Free Chlorine. Using a 10-ml tube, add 0.5 ml each of Reagents 1 and 2 and fill to mark with sample.

Combined Chlorine. Add about six small crystals of KI (approximately 0.1 g), mix rapidly to dissolve, then let stand 2 min. The increase in color corresponds to the quantity of combined chlorine.

To subdivide the combined chlorine into mono- and dichloramine, introduce an intermediate stage, using (for 10 ml total volume) one very small crystal of KI or one drop of 0.5 per cent solution in a manner similar to that given for the volumetric method. To check for NCl_3, add this amount of KI to the specified amount of Reagent 2, then add sample, and, finally, Reagent 1. Any increase in color compared with the normal free-chlorine reading indicates the presence of NCl_3. Estimate can then be made as described under volumetric method.

Calibration of Colorimeters

For calibration of colorimeters use a standard potassium permanganate solution of 0.802 g per liter. Dilute the solution ten times so that 1 ml made up to 90 ml with distilled water is equivalent to 1 ppm chlorine. Using required amount of potassium permanganate solution, make up to 90 ml with distilled water. Pour into flask containing 5 ml each of Reagents 1 and 2, and mix. Then fill colorimeter tube and take reading. If desired, titrate remaining contents of flask against FAS solution as a check on the standard color (and on any absorption of permanganate by the distilled water used), using the appropriate volume correction factor. For example, where 10-ml colorimeter tubes are used, the factor is 100/81.

Interference by Oxidized Manganese

If it is necessary to allow for interference by oxidized manganese, the procedure to follow is similar to that of the neutral orthotolidine method, except that the DPD indicator is used in place of orthotolidine. The procedure is as follows: Place 5 ml of Reagent 2, one small KI crystal, and 0.5 ml of 0.5 per cent sodium arsenite solution in a titration flask. Add 100 ml of sample and mix. Then add 5 ml of Reagent 1 and mix. Any red color is titrated with the FAS solution or measured colorimetrically. Subtracting the figure thus obtained from the Fraction 1 reading of the normal procedure gives the corrected free chlorine reading.

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Stray-Current Corrosion of Underground Distribution Systems

Donald W. Barron

A paper presented on Feb. 14, 1957, at the New Jersey Section Meeting, Newark, N.J., by Donald W. Barron, Pres. & Engr., Albert F. Ganz Inc., South Orange, N.J.

THE corrosion of metals, particularly as the formation of rust when iron and steel are exposed to the action of the elements, is familiar to everyone. It is known that such exposed metal surfaces must be periodically painted, coated, or otherwise protected to prevent this rusting action.

Underground metallic structures are also subject to corrosion. Practically none of the common metals is found as a metal in its natural state and, when unprotected, those metals tend to revert to that natural state as an oxide or other chemical compound.

The presence of electrical currents, particularly direct currents, will cause corrosion under certain conditions and will protect a metal against corrosion action under other conditions.

Origins of Corrosion

Corrosion may be defined as the destruction of a metal by chemical or electrochemical reaction with its environment. In general, the corrosion of underground piping systems is electrochemical in nature and is dependent upon the presence of an electrolyte and the availability of oxygen. Sea water, natural fresh waters, and soil waters are liquid electrical conductors or electrolytes. Because of the normal presence of moisture in soils, earth in general is considered an electrolyte.

The electrochemist would explain that corrosion takes place at the metal surface (an anode) where positive metal ions enter the solution and negative electrons are given up. These electrons pass through the metal to that part of the metal surface (the cathode) where they are accepted and combine with positive ions in the solution. Conventional electrical current flows in the direction opposite to the flow of these electrons. Corrosion, therefore, takes place at the anodic surfaces where electric current enters the solution but does not normally occur at the cathodic surfaces where electric current is picked up by the metal.

The electric current which is a part of the corrosion process can be externally applied, in which case the corrosion is termed electrolytic. This is the action which is usefully applied in the electroplating industries and in the charging of storage batteries, but, at the same time, which has accounted for an untold number of failures on underground pipe and cable systems. It is then known as electrolysis or stray-current corrosion.

On the other hand, the electric current which is a part of the corrosion

process can be self-generated by the formation of galvanic cells. Many factors can cause this, including the interconnection of different metals which are in the same electrolyte, a single metal having its surfaces in differing environments, the presence of impurities on the metal surface, and different concentrations of oxygen, acids, and alkalies in the electrolyte at various areas of a metal surface.

The self-generating action takes place, for example, in a standard dry-cell battery or in a storage battery when it is connected to a load and is discharging. It is also the action (known as galvanic corrosion) which corrodes an underground iron pipe metallically connected to a copper pipe.

The cathodic protection of an underground water pipe is based on the principle that the passage of electric current from a metal surface into an electrolyte causes corrosion while the pickup of electric current from an electrolyte protects the metal from corrosion action.

Transit System Effects

Originally the principal source of stray currents, with the resulting electrolysis problems, was the grounded running rails of direct-current, single trolley, railway systems. Electrolysis conditions were aggravated by inadequacies which frequently developed in the railway power distribution and return circuit systems occasioned by the phenomenal growth of this method of transportation in the urban and suburban areas of many cities.

Later rapid transit systems—elevated and in underground and under-river tunnels—were installed with a third rail instead of an overhead trolley wire. Local and long-distance railroads which have been electrified, also use a third rail or an overhead catenary. In all installations the grounded running rails were used as the basic negative return circuit system.

From the electrolysis standpoint the production of stray currents is fundamentally the same in all these systems. Electric power is supplied to the electric car, train, or locomotive from the powerhouse or substation by an insulated positive feeder system and returned to the power supply by the track system and negative feeders. The return current in the rails produces a track voltage drop which raises the electrical potential of the track with respect to earth in areas remote from the power supply and lowers the potential of the track with respect to earth in the vicinity of the negative feeder connection point which, in a simplified design, is at or near the power supply station.

Because the running rails are not insulated from the ground, some of the return current strays from the track in areas remote from the power supply, flows through the earth and returns to the track as it approaches the negative feeder connection point or points.

Any continuous underground metallic structure such as a water pipe system in the general area of the track will pick up a portion of this stray current in areas remote from the power supply station, and discharge it to earth in the vicinity of the negative feeder connection points. This area, usually in the vicinity of the power supply station, is rather restricted. It is known as the positive area where corrosion of the pipes will occur.

In the extensive negative areas remote from the power supply station, the pipes are actually gaining cathodic protection by the pickup of stray current, thus protecting them from galvanic cell

or local soil action which otherwise might be experienced in widely scattered areas.

It has been possible to minimize stray currents from electric railway systems by making changes in the existing systems and incorporating special design features in new systems. Railway companies, for example, have installed insulated negative return feeder systems to take current from the running rails at several locations instead of from a single location in the immediate vicinity of the power supply station; they have given greater consideration to rail bond maintenance to ensure better rail conductivity; they have installed negative tie feeder cables between parallel or diverging track lines; and, occasionally, they have installed new power substations to eliminate excessive feeding distances.

A great many negative return copper feeders have been installed by the Hudson & Manhattan Railroad which connects New York to Newark and other New Jersey communities. The Delaware, Lackawanna and Western Railroad has several power substations in its electrified division, and each one has a negative return feeder system. The Lackawanna also uses a 3,000-v d-c power system, in which the magnitude of the load currents is much less than it would have been if the usual 600-v system had been installed. Because of the heavy power requirements of the railroad trains, however, and even though the operating voltage is high, return circuit currents are also high, so that considerable voltage drops are produced in the rails with correspondingly high stray currents.

The more recent additions to the New York City subway system employ smaller and more frequent substations together with extensive insulated negative feeders and other means to reduce stray currents to a minimum.

Electrical Drainage

Other mitigative measures have been employed by the operators of underground pipe and cable systems. In one of the most common means of protecting underground cables, known as cable sheath drainage, insulated cables are connected to the cable sheaths in the vicinity of the power substation and are extended to the negative bus of the substation. By taking current from the cable sheaths over a metallic conductor directly to the railway negative bus, the potential of the cable sheaths is lowered with respect to the tracks and earth, and corrosive action will be precluded. If only one cable system is thus drained to the railway negative bus, however, corrosion exposures can be aggravated on other underground cable and pipe systems in the same territory. Local corrosion conditions may be set up on the other pipes and cables even in areas where those structures are negative in potential to the railway tracks.

Electrical drainage can similarly be applied to underground pipe systems. Because cast-iron bell-and-spigot pipe joints, even when they are made up with lead, can have high electrical resistance, however, water pipe failure have occurred where the current shunts around such joints through earth. Pipe joint corrosion can occur in areas where the pipes have been considered protected.

It is most important that, when electrical drainage is applied to any underground structure, all operators of underground structure systems in the territory cooperate in the mitigative

work so that the best possible solution for all concerned may be adopted.

The use of nonmetallic jointing materials tends to give all pipe joints, high electrical resistance, thereby decreasing the tendency for mains to pick up and transmit stray currents. Pipe drainage should then be avoided.

Intentional insulating joints have frequently been installed in a water main system and, sometimes, in water service pipes to isolate sections of pipe which otherwise would be affected by stray-current corrosion.

Pipe coatings, wrappings, and encasement in insulating materials have often been employed to protect pipes exposed to electrolytic action. The coverage, however, must be perfect or aggravated corrosion will occur where there are flaws in the coating and other unprotected spots. Nonmetallic pipe has also been installed to obviate corrosion damage.

When pipes have been subjected to corrosion exposure from stray currents, cathodic protection has been applied and is frequently being used to supplement pipe coatings.

In Germany, probably before 1910, a ground plate was buried between a pipeline and the streetcar tracks in the vicinity of a railway power supply station, and what was then called an auxiliary dynamo was connected between the pipe and the ground plate, so that current was removed from the pipe and delivered to the expendable ground plate.

The late Albert F. Ganz experimented along similar lines as early as 1912. Later he designed a permanent installation to protect the 60-in. gas main which extended from the Astoria to the Ravenswood sections of New York City in a tunnel under the East River, by removing 60–70 amp of stray current by means of a motor–generator set and a ground bed consisting of large pieces of discarded steel railroad car bottoms placed in the East River.

Special Conditions

Many special incidents of stray-current corrosion on water pipes require special treatment. Stray current, for example, can be picked up by pipes and cables in areas near electrified railways remote from their power supplies. The current may then flow on the pipes and cables to a low-resistance earth or sea water area, also remote from the railway power supply, and there be discharged to earth, causing corrosion. Such conditions might be expected to prevail in the environs of the New Jersey Meadows. Stray-current effects of a substation may be experienced in the area of another quite removed from the first. During the period of direct-current operation of the Pennsylvania Railroad, the Hudson & Manhattan Railroad experienced the effects of the Pennsylvania substation in the New Jersey meadows as far as New York City, a distance in which several other substations intervened.

Reports have been made that tests conducted on various underground structure systems in the easterly Union County N.J. area have indicated the influence of such electric railway systems as the Lackawanna, Hudson & Manhattan, Staten Island Rapid Transit, and even the New York City subway system. Changes in pipe currents on a pipe system near Elizabeth, N.J., were attributed to the operation of the Lackawanna Power substation at Bernardsville, N.J.—approximately 20 miles away.

In investigating corrosion conditions on a pipeline beyond the end of an interurban trolley system, stray cur-

rent on the pipe was traced to and through an area of low-resistance earth to a point approximately 10 miles beyond the end of the track.

The fact that a water pipe system is not contiguous to the route of an electric railway system cannot always be taken as assurance that stray-current problems will not exist.

A more-or-less local water pipe system may be affected by stray railway currents and suffer from corrosion action even though it does not extend to an area near a railway power supply station. Such a system can pick up stray current in one area, discharging it to earth near its opposite limits, which may be in the vicinity of the railway tracks or low wet ground bordering an adjacent water system.

Water pipes and services which come near or cross underground cables that are electrically drained to a railway negative bus may be susceptible to local corrosion action.

Under certain conditions other sources of stray current can create more-or-less local electrolytic corrosion problems. Stray currents which originate in direct-current light and power distribution systems, may be involved, particularly in certain industrial plants. Stray current from cathodic protection systems installed to protect some other underground pipe or structure system may also create corrosion.

It is theoretically possible for stray alternating current to cause corrosion, but the amount of such corrosion on pipes is very much less than the effects of direct currents of the same magnitude. A few corrosion incidents which might have been attributable to alternating stray current have been experienced, where, for example, there had been a rectifying action on lead-sheathed cables. Electrolysis problems with pipes, however, do not seem to be serious or frequent.

Grounding Practices

The almost universal practice in this country of grounding the secondary neutrals of electric transformers to the water pipes in buildings causes alternating currents to flow on house piping, water mains, and other metallic structures not designed to be electrical conductors. In areas where stray railway currents are present, such ground connections and the electrical neutral conductors can aggravate the electrolysis problem by transferring the stray current from one section of the pipe system to another which may either have been isolated by insulating joints for corrosion protection or not otherwise exposed to electrolysis conditions.

Many complaints of sparking, electric shock, and other hazards associated with the use of water pipe grounding practices have greatly concerned water works operators.

As a result of using bare neutral wiring in electrical distribution systems, 25–75 per cent of the total neutral current flows over house piping and other metallic structures. AWWA has made a thorough study of this practice (*1*) and has opposed it.

Conclusions

Enough cannot be said of the importance of cooperation with other utilities and operators of underground structures in corrosion matters. The New Jersey Committee on Corrosion is a state-wide organization fostering such cooperation and acting as a clearing house for corrosion information. Whenever an organization plans to install cathodic protection or contemplates some change which may release

stray currents and thus affect other underground systems, all member organizations are notified in advance, and interested operators are given the opportunity to participate in joint tests so that modifications may be made or additional measures may be undertaken by them to ensure that no undesirable conditions may evolve.

Many water works operators may think that, because most of the electric street railway systems are being displaced by buses, corrosion problems are over. Cases of corrosion failure have occurred a number of years after an electric street railway was abandoned when the corrosion started under stray current conditions and continued as a result of the pipe environment. Even in former negative areas, where pipe failures were never experienced, other types of corrosion action can develop on water pipes. This has been the experience on many underground cable systems.

When planning extensions and large-scale renewals in a water pipe system, it is expedient to give due consideration to the possibility of the existence or creation of corrosion conditions. It has been found through experience that the inclusion of precautionary measures in the original design and construction of a new extension to a pipe system will be more satisfactory and economic than the application of subsequent mitigative measures.

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Duties and Qualifications of Operators of Small Water Works

Walter F. Rowland

A contribution to the Journal by Walter F. Rowland, graduate student at the University of Illinois, Urbana, Ill.

THE purification of surface waters is, in general, far more complicated than the treatment of ground waters. Cities of greater than 10,000 population which depend on surface sources for their water supply can usually afford to employ qualified, full-time, water works operators. In smaller communities, however, or in those communities that treat less than 1 mgd of surface water, the operators may frequently, by necessity, be hired on the basis of their willingness to accept the job, rather than for their qualifications. A study has been made, therefore, to determine the general qualifications of water works operators in Illinois communities that treat less than 1 mgd of surface water.

Study Data

This study was conducted by sending questionnaires to the 86 Illinois communities in the above classification. Replies were received from 43 per cent of these communities, with 6 per cent reporting pumpages now in excess of 1 mgd. The analysis is, therefore, based on the replies from 32 municipalities.

All the reporting communities purified the surface water by rapid sand filtration and chlorination, but only 16 per cent softened the water, and only 3 per cent added fluorides. Nine per cent of these public water supplies were privately owned. The populations of the municipalities ranged from 726 to 10,592, with pumpages ranging from 27,000 to 800,000 gpd. The number of operators employed varied from one to four, with 41 per cent of the communities employing only one operator; 31 per cent, two operators; 3 per cent, three operators; and 25 per cent, four operators. The salaries received by these operators ranged from \$135 to \$350 per month. In 33 per cent of the communities, the water works superintendent was the only person responsible for the operation and maintenance of the water system, and, usually, for the maintenance of either the streets or the sewers as well.

The operators had, almost uniformly, initially received "on-the-job training" only to qualify them to operate the treatment plant. Thereafter, their knowledge of water treatment and operations was increased mainly by studying the technical literature and by conversation with state public health personnel and equipment manufacturers' representatives. The Illinois Department of Public Health and the University of Illinois annually sponsor a water works operators short course, but only 28 per cent of the operators had attended one or more of these courses. Also, these operators were mostly men who had 10–30 years of water works experience.

TABLE 1

*Data on Water Treatment Plants and Operators in Thirty-Two Illinois Communities**

	Population				
	726–1,000 (Median: 900)	1,001–2,000 (Median: 1,275)	2,001–3,000 (Median: 2,375)	3,001–5,000 (Median: 3,825)	5,001–10,592 (Median: 8,500)
Pumpage—1,000 gpd	27–331	50–150	100–250	200–300	550–800
Median	45	100	200	250	725
Number of hours operated daily	4.5–21	7–24	8–18	8–24	12–24
Median	7.5	10	11	11	24
Number of personnel	1–3	1–5	2–5	1–3	2–6
Median	1	2	3	2	5
Number of operators	1–2	1–4	2–4	1–2	2–4
Median	1	1	2	2	4
Monthly salary (Operator)	$135–$240	$150–$330	$192–$245	$185–$265	$245–$350
Median	$200	$250	$210	$248	$280
Monthly salary (Superintendent)	$135–$260	$250–$330	$250–$325	$245–$400	$325–$450
Median	$200	$280	$275	$285	$335

Population	Operator's Duties	Superintendent's Duties
726–1,000	Water works superintendent and operator; meters and taps; maintenance and repairs; all clerical and administrative tasks. (Fifty per cent of these personnel also performed city street maintenance.)	
1,001–2,000	Water works operator; meters; maintenance and repairs. (Fifty per cent operated sewage plant, 30 per cent did street maintenance.)	Water and sewage works superintendent and part-time operator.
2,001–3,000	Operate and maintain water system only.	Water and sewage works superintendent and part-time operator.
3,001–5,000	Water and sewage works operator.	Water and sewage works superintendent and part-time operator.
5,001–10,592	Operate and maintain water system only.	Water works superintendent only.

Certification

The state of Illinois has enacted legislation for the compulsory certification of sewage treatment plant operators, but has, as yet, failed to require the certification of water treatment plant operators. This seems rather paradoxical, as the health and welfare of a community is far more dependent on the purity and adequacy of its water

supply than it is on the proper disposal of its sewage wastes. It is interesting to note that only one community reported that it employed certified water works operators. Even so, the conclusion that all uncertified operators are unqualified to operate a water treatment plant is unjustified. If a new operator is given adequate initial instruction by fellow operators and if he studies diligently, he will, after many years of experience, become extremely well qualified to operate his own or similar plants. It should be both recognized and accepted, however, that no person should be given the responsibility of operating a water treatment plant until he has adequately demonstrated by state certification, that he has the ability to do so.

Analysis

The reported information has also been analyzed on the basis of population ranges, with the analysis summarized in Table 1. Because of the extreme variations of the several items in each population group, average values are meaningless, and median values are reported instead.

It is again emphasized that the water treatment plant operator is vital to the health of the community as producer of safe, palatable water, and to the safety of the community as provider of adequate water to fight fires. From a study of Table 1 it is apparent that in communities of less than 2,000 population the operators are given so many duties that it is generally impossible for them to fulfill any of them adequately. If the operator is compelled to spend more of his time on some duty other than operation of the treatment plant, or if he is unable to provide proper system maintenance, the responsibility for any outbreak of a waterborne disease, or for the failure of the water system should rest upon the citizens of the community who originally insisted that the operator be assigned these additional tasks.

It is also noted that operator responsibility is greatest in the small community which can afford only one man to operate and maintain the water system —and, often, to maintain the streets or sewers as well. These lone operators usually do a good, if not heroic job of fulfilling their obligations. There are, however, very few qualified operators who are willing to shoulder this responsibility for $200 a month without feeling, and being, grossly underpaid.

Certification of Water Works Operators in Illinois

William J. Downer

A paper presented on Oct. 25, 1956, at the Iowa Section Meeting, Des Moines, Iowa, by William J. Downer, Asst. Chief San. Engr., State Dept. of Public Health, Springfield, Ill.

THE Illinois plan of voluntary certification for water plant operators saw its first certificate of competency issued in 1938. Several years of preparation were needed before the plan became a reality and, since that time, there have been many reversals by the state legislature to the plan to license officially water plant operators.

The first real interest in certification was voiced at the first meeting of Illinois operators sponsored by the State Department of Public Health in 1932. The certification question was raised because of the insecurity felt by many water plant operators appointed to their positions by municipal officials or, more specifically, directly by the mayor. At that time, with a change in local administration one could expect a change in water plant personnel. The health department had tried to impress on municipal officials the importance of competent operation of water utilities and the resultant dangers if operation was not in satisfactory and competent hands. Large personnel turnover in the water department, moreover, meant that the health department had to spend considerable time training new personnel. Most municipalities, at that time, held elections every 2 years. The State Department of Public Health was thus interested in certification as a method of stabilizing the situation.

Departmental Powers

The general powers and duties of the department of health relative to water supply, found in Illinois statutes (*1*), are:

> To act in supervisory capacity relative to the sanitary quality and adequacy of proposed and existing public water supplies, water treatment and purification works, and to prepare and enforce rules and regulations relative to the installation and operation of public water works so that public water supplies will be of satisfactory sanitary and mineral qualities for drinking and general domestic use; to determine standards of purity of drinking water; to establish and enforce minimum sanitary standards for the operation of public water supplies; to require the submission of plans and specifications for public water installations, changes and additions, excepting distribution piping beyond the consumer's service or building service connections; and to prepare and enforce rules and regulations relative to the preparation, submission, and department approval of such plans and specifications.

On the basis of these powers the department requested an opinion from the attorney general as to whether it

could issue certificates to superintendents, chemists, and operators of water treatment plants. The department further asked if, in the event it did not have the authority to prohibit those not holding certificates from fulfilling their functions, certificates could be issued as merit awards. In his answer, the attorney general stated that it was his opinion that the provisions granted powers of supervision and regulation and did not authorize the State Department of Public Health to require that superintendents, chemists, and operators receive certificates from the department before performing any functions at water treatment plants. He further stated that: "The certificate which you propose would be in the nature of a license permitting persons to be employed at these water plants." It was the opinion of the attorney general that special statutory authority would be necessary to enable the department to impose these conditions of employment. The department, however, was authorized to make reasonable sanitary rules and regulations governing employment of persons in treatment plants, and there would be no legal objection to issuing certificates in the form of merit awards to operators who had faithfully observed the rules and regulations of the department.

Initial Action

On the basis of the attorney general's opinion, the department decided to initiate the voluntary certificate of competency plan, based entirely upon training and experience, with the thought that some day, in the near future possibly, licensing would be a reality and this could be a stepping stone toward such legislation. A committee, appointed at the annual water plant operators' meeting in 1936 to discuss the feasibility of a voluntary certificate of competency, recommended that the State Department of Public Health be asked to go ahead with the plan discussed and that a temporary committee consisting of one representative from each of the operators' groups at the meeting, the senior professor of sanitary engineering at the University of Illinois, and the chief sanitary engineer of the State Department of Public Health be empowered to set up a detailed program for issuance of voluntary certificates. In 1937 the temporary committee reported on its progress to the annual meeting of the water plant operators. The report was accepted, the State Department of Public Health agreed to handle all the necessary detail work and the committee, as such, passed out of existence. Its members then became part of an advisory committee to the department of health on matters dealing with certificate of competency questions.

The report of the temporary committee stated that certificates of competency were desirable, and that the basic reason for their issuance was to give recognition of water works operators' qualifications and meritorious service in the performance of their duties. The temporary committee also expressed the desire that there be no pressure exerted on any operator to apply for a certificate of competency. Certification should be purely optional and voluntary on the part of the water treatment plant operator. The committee further suggested that certificates be given for three grades of operators.

Class A operators should: [1] have an education of 4 years of high school or its equivalent; [2] have 5 years experience in water treatment plant opertion, of which 2 years should represent

responsible charge of plant operation; [3] be able to make or supervise the necessary physical and chemical laboratory plant control tests, and be generally familiar with the laboratory procedure, technique, and interpretation of bacteriological analyses; [4] be informed, in general, on the maintenance and operation of all mechanical equipment and devices in plant; and [5] be responsible for operation and supervision of plant.

Class B operators should: [1] have a grammar school education or its equivalent; [2] have 3 years experience in water treatment plant operation; [3] have sufficient knowledge of physical and chemical laboratory control tests; and [4] have a general knowledge of the maintenance and operation of all mechanical equipment and devices in plant.

Class C operators should: [1] have a grammar school education or its equivalent; [2] have 1 year experience in water treatment plant operation; and [3] have knowledge of the procedure and interpretation of the necessary control tests.

Education Factor

The committee felt that, although it was necessary to allow credit to those individuals who had a higher education, it was also necessary that all classifications be kept open to those who had limited schooling but had achieved various degrees of practical education through experience in water treatment plant work. A person having 1 year of operational experience or 6 months in responsible charge of plant operation was to be considered as having the equivalent of 1 year of high school work, and satisfactory completion of a recognized course in water treatment plant operation was to be considered as equivalent to 2 years of high school work.

In determining the educational equivalent, however, the years of experience required in the class for which application was made were first deducted from the total experience of the applicant. An operator who applied for a Class A certificate, for example, and who had 8 years of operation experience of which 3 were spent in responsible charge of his plant, deducted 5 years' experience. This would leave 3 years of experience, all spent in responsible charge, considered as equivalent to 6 years of high school work, making the applicant eligible for a Class A certificate as far as the educational requirement was concerned.

An applicant for a Class B or Class C certificate needed the equivalent of a grammar school education as evidenced by his ability to read, write, and perform the arithmetical computations to keep the necessary records.

Experience Factor

The committee acknowledged that experience in actual operation work and the ability of the applicant to bear responsibility should be given recognition in establishing qualifications for competency certificates. The term "responsible charge" referred to operation experience with executive responsibility and was made to include only experience as a water plant superintendent. It will be noted that an applicant for Class B or C certificate, needed no experience in responsible charge, but were required to have a certain specified amount of experience in some phase of plant operation.

The requirements remained the same until 1940, when a new class—Class AA—was established. The addition came as a result of the discovery that

there were a number of water treatment plant operators whose qualifications were above those of Class A. At the same time, it was felt that, as the sewage treatment plant operators had set up qualifications for their plants, the water plant certificate of competency standards should be comparable. The highest grade of sewage operators required considerably higher standards than those of Class A. Instead of reclassifying the entire personnel who had already received certificates, a new class was added. The requirements for Class AA were that the operator should: [1] have 4 years of university work in chemistry, or civil, sanitary, mechanical, or chemical engineering, or equivalent work; [2] have 6 years of experience in water treatment plant operation, of which 4 years were to represent responsible charge of plant operation; [3] be able to make and supervise the necessary laboratory physical, chemical, and bacteriological plant control tests and their interpretation; [4] be in charge of the maintenance and operation of all mechanical equipment and devices for proper operation of water treatment plant; and [5] be responsible for operation and supervision of a plant.

It also became possible for an operator who was not a college graduate to meet the college educational requirement in that 2 years of operational experience or 1 year in responsible charge of plant or satisfactory completion of a recognized course in water treatment plant operation was to be considered as the equivalent of 1 year of college work.

In 1940, the State Department of Public Health and the advisory committee proposed that the voluntary certificates of competency for water treatment plant operators be extended to include operators of water supplies in which no treatment was involved. Educational and experience requirements were set at a minimum—grammar school or equivalent and 1 year of experience. All Illinois utilities personnel were contacted, but so few showed any interest that the plan was never established.

The class of certificate that an operator receives is based entirely upon training and experience, and no examinations have been held, nor is it contemplated that any will be held. It has been necessary, however, to refer several applications in the past to the advisory committee for a decision on the type of classification an operator should obtain.

When an operator desires to be considered for a certificate of competency he makes application to the department of health. In the application form, he is asked to submit three letters of recommendation, and considerable weight is placed on both their contents and the position of the recommending person in the community. If the grade of the applicant is below that of a chief operator, one of the references must be from the chief operator, superintendent, or a member of the water works committee.

Encouragement and Opposition

In 1940, the Illinois Section of AWWA adopted a resolution at its annual meeting urging "all eligible persons to apply for license." This resolution served to unite water works personnel behind certification and to announce the value of trained personnel to the public.

With the outbreak of the typhoid fever epidemic at the Manteno State Hospital in 1939, considerable interest was aroused in licensing of water works personnel and the necessity of having qualified operators in a utility which

was so vital to the health of every citizen in the community. A bill was introduced in the 1941 senate of the state legislature for the licensing of water plant operators. The bill never became law and, in 1946, the Illinois water plant operators appointed a licensing committee which did considerable ground work in helping to prepare another bill on licensing. The bill proposed to the 1947 legislature that an examining board made up of the director of public health, the senior professor of sanitary engineering at the University of Illinois, three members appointed by the governor (one to be a municipal official and the two others to be qualified operators) be set up. The board would have the privilege of establishing minimum qualifications, and the license would be issued by the State Department of Registration and Education, inasmuch as that department handles all licensing of persons within the state government. The bill was referred to committee where considerable objections from organized labor officials were raised. It was mutually agreed in committee, therefore, that if the operators cared to submit another bill in 1949 it might be possible to work out with the union officials legislation satisfactory to organized labor. A similar bill was introduced in 1949 but for a third time failed to pass because of organized labor's opposition. Although no bill to date has managed to progress past the committee stage, an understanding was reached that activities towards licensing would be withdrawn temporarily to allow organized labor to find a satisfactory solution for the next session. It is interesting to note, however, that although legislation to license water plant operators was not forthcoming in the 1949 session, the Sanitary Water Board Law (*2*) was completely revised. In the law, which deals broadly with the prevention and abatement of stream pollution in Illinois, the board was given power to license sewage treatment plant operators. Again, in 1951, a bill for licensing was introduced and organized labor again offered objections, principally on the basis that in several of the larger water plants in the state (especially in Chicago) the operators were members of the operating engineers union and there was no need that another agency determine qualifications for the requirements to perform the duties of a water plant operator. During discussions with the leaders of organized labor and those legislators interested in licensing, however, it was agreed that the bill for licensing water plant operators be dropped and that a public water supply control law be introduced instead. The bill (*3*), which passed, gives the department of health powers relative to the sanitary quality, mineral quality, and adequacy of a supply. It also states that, whenever a supply becomes contaminated or is subject to contamination, the department may hold a hearing and issue orders for the necessary corrections. Under the same bill, the department requires the submission of plans and specifications for all new or improved water works facilities. The department also requires the submission of samples for analyses and copies of operating reports. Owners and operators of water utilities are responsible for the qualifications of their operating personnel, however. The operators and others interested in licensing, realizing the impossibility of having a licensing law passed in Illinois, withdrew their support for a licensing act, so that organized labor backed the Public Water

Supply Control Act which was passed in the 1951 legislative session.

It is interesting to note that in Illinois, at the present time, those who must hold a license before being allowed to practice their profession include not only physicians, chiropractors, osteopaths, midwives, and many others in the medical field, but also funeral directors, barbers, beauty operators, and automobile drivers.

Present Status

At the present time, 437 certificates of competency have been awarded—34 in Class AA, 89 in Class A, 206 in Class B, and 108 in Class C. There have been 27 who changed from Class C to B; 25 from Class B to C; and 8 from Class A to AA. It is to be noted that the certificates are only for water treatment plant operators and that the 437 certificates issued represented operators from 139 plants. As there are 317 points of supplies which provide some type of treatment in Illinois, only a little more than 30 per cent of total treated supplies have an operator holding a certificate of competency. In 1949, approximately 50 per cent of treated supply points had a certified operator.

Certificates are issued to the operator and have no relation to the size of the plant, as it is felt that the same principles of treatment apply in both large and small plants.

There has been no concerted effort on the part of the committee, the water works operators organizations, or the State Department of Public Health to urge or promote this voluntary plan. There is no requirement that an operator must obtain a certificate. At the present time the issuance of a certificate is part of the health department's program to promote the efficient and economical operation of water treatment plants, so that there are no assessments or fees necessary to obtain the certificate.

Many unusual and interesting angles have developed with the issuance of certificates of competency. The program has reflected credit not only on the water works operator, but, in the words of a city official: "The mayors and councils are the ones who really benefit from this idea, for when a man working for you receives recognition, the boss also comes in for a share of the credit." A newspaper in a good-sized city said: "Our city is to be congratulated that a man of that class is in charge of such vitally important work." For the first time in many areas, the community leaders, who most often submitted letters of recommendations for the personnel, have taken a personal interest in the water works and its personnel. The Illinois master plumber's publication stated:

> It may be added that neither sewer systems nor water supply systems operate entirely automatically—they require the constant attention of men who know their business if they are to function so as to provide pure water and eliminate sewage in a way that maintains sanitation. These certificates issued by the Division of Sanitary Engineering extend a long-delayed and long-merited recognition to a class of public employees that come rarely to public attention but upon whose efficiency and integrity the health of communities depends in no small measure.

Generally, with a voluntary plan only the qualified and interested take an active part in obtaining recognition—the unqualified and the uninterested have little incentive to become certified. A voluntary plan is of little, if any, value to an operator desirous of holding a job or gaining advance-

ment, unless the owners and operators of water supplies desire to be guided by such a voluntary program. There were high hopes among the operators that the starting of a voluntary plan could be a stepping stone for licensing, but these hopes have been banished. The department of health, however, has heard of several veterans who, when returning to their jobs, received better ratings because they held certificates. Another example of the certificate's value has been given by several Illinois state penitentiaries having water treatment plants. Officials encouraged the inmates who work at the water plant to obtain certificates of competency, and several have been issued. Although no parolee is known at present to be employed in a public water plant, during the last war several obtained such positions in the service when they produced certificates of competency from the State Department of Public Health.

The certificates of competency in themselves have not been of much help to the department of health except as a way of finding out the basic qualifications and interest of those employed at the water treatment plant. Under the voluntary plan, the department has no power to require the dismissal of incompetent operators or the hiring of qualified ones. This is still the responsibility of the owners and operators of public water supplies in Illinois. The plan, however, does tend to promote the efficient operation of water treatment plants, which is a part of the program of the department.

References

1. Illinois Revised Statutes, Par. 55, Chap. 127.
2. Illinois Revised Statutes, Par. 145.1 *et seq.*, Chap. 19.
3. Illinois Revised Statutes, Par. 121a *et seq.*, Chap. 111½.

Developments in Well Production and Maintenance

Panel Discussion

A panel discussion presented on Mar. 21, 1957, at the Illinois Section Meeting, Chicago, Ill.

Madison, Wis.—*Elmer L. Nordness*

A paper presented by Elmer L. Nordness, Supt. of Water Works and Sewerage, Madison, Wis.

IN the Midwest, particularly in Minnesota, Iowa, Illinois, and Wisconsin, a considerable number of the public water supplies are obtained from deep wells. This is also more or less true of North and South Dakota, Kansas, and Nebraska, as well as of other more limited areas in the United States. For the most part, well water is drawn from sandstone formations. The technique of developing such wells has improved tremendously in the last decade. In the Wisconsin area, electric power is abundant and rates are reasonable, so that electric pumping is used in a substantial majority of these installations. This has resulted in the development of so-called unit wells, which are self-contained pumping stations from which the water is pumped directly to the distribution system. In smaller communities, with populations of 5,000 or less, generally one well—with elevated storage—is sufficient. As cities increase in size, unit wells are located at various points throughout the city as required. In Madison, at present, there are ten separate units, in addition to a steam-powered pumping station. It is expected that two new unit wells will be developed in 1957.

When the steam-powered station was built 39 years ago, it was felt that such a station independent of electrical power was needed because of the possibility of electrical outages. In the early days, this was necessary, but with the increased reliability of electric service, this factor is no longer as important. Almost all of the electric units are equipped with turbine or centrifugal pumps which operate most efficiently through a comparatively small range of pressure. The steam-powered station is equipped with horizontal cross-compound pumping engines which are governed by the pressures in the distribution system, thus reducing fluctuations in pressure to a minimum and enabling the electrically driven units to operate at their highest efficiency.

Wells at Madison

The city of Madison has always obtained its supply from deep wells. A brief discussion of the local development of the deep wells in the last 60 years may be desirable because it is more or less typical. The first wells drilled in the early 1880's were of 4- and 6-in. diameters and, up to the year 1910, the largest diameter was 8

in. In 1910, 10-in. wells were developed. This diameter increased to 16 in. by 1924. In 1930, and since that date, wells from 24 to 36 in. in diameter have been developed, the largest size in Madison having an outer casing of 37 in. Ground water supplies are logically divided into shallow supplies and deep-well supplies. Shallow supplies consist of water from lakes, rivers, and sand and gravel formations rather close to the surface of the ground. The deep-well supplies consist of those obtained from the consolidated formations which generally occur below 50 ft. In the midwestern well areas, there is invariably an impervious layer of clay or shale between the loose formations and the sandstone rock. This impervious layer of clay separates the shallow water from the deep-well water. A rather spectacular example of this occurred in a local well drilled several years ago. This well was drilled less than 300 ft from one of the lakes in Madison and, when the well was fully developed, the static level was 30 in. above that of the lake—which indicated very clearly that the water from the deep well was definitely separated from the surface waters. In Madison, the top of the rock is found at a depth of 750 ft, so that the well proper extends through 700 ft of sandstone. The sandstone formations are not uniform and, in the upper layers, considerable iron formations are found. Water pumped from these formations generally carries 1–3 ppm iron, which is definitely objectionable. It is more economical to case off this water rather than provide the iron removal plant which would be necessary if the water were to be used.

Construction

In the construction of Madison's wells, a large outer casing is used, generally 30 in. in diameter. This casing is driven through unconsolidated formations into the top of the rock which is generally more or less decomposed. Attempts are then made to drive the outer casing down into the rock about 10 ft, at which point the solid formations are usually encountered. The hole diameter is then reduced to about 28 in. and drilled below iron-bearing formations where the 24-in. inner casing is set and grouted in. A 22-in. hole is then continued to granite, a careful record being kept of the formations encountered.

The inner casing has a depth of from 100 to 300 ft, depending upon the depth of the undesirable sandstones which are found. After drilling is completed, a test pump is installed and a test is run to determine the specific capacity of the well.

Having a straight hole in the top 400 ft of the well is extremely important. Pumps will not run long in a crooked hole and the failure always seems to come during heavy pumping periods.

Shooting of Wells

The specific capacity of a well is the rate of pumping in gallons per minute divided by the number of feet of drawdown. If the specific capacity is 20 or more, no shooting is done because the sandstone formations are generally rather soft. In the majority of cases, however, the specific capacity is only 10–12 and shooting of the well is desirable.

In consolidated formations where the specific capacity of a well is rather low and where the rock formations are hard, the quantity of water which can be obtained from a well may sometimes be increased by shooting. Shooting a well consists of lowering into the well

an explosive provided with a detonating cap and a pair of wires which extend to the surface and by which the cap and explosive can be detonated. There are many factors to be borne in mind if this procedure is to be undertaken and some of the most important are:

1. Shooting a well should not be undertaken except upon the advice of an experienced person, as the location and size of shots are important in securing best results. In some states, a licensed blaster is required. This possibility should always be checked before blasting.

2. Both pressure and temperature tend to influence the effectiveness of explosives. Therefore, a recommendation from the company furnishing the explosive is desirable. In the Middle West, shots of 50–200 lb of 80 per cent high-velocity gelatin are used in wells of 16 in. diameter or larger.

3. The container for the explosive should preferably be cast-iron soil pipe or a galvanized-iron container sufficiently strong to prevent water from coming in contact with the explosive. It should be as large in diameter as possible, contingent upon the size of the hole, because the water between the bomb and the side of the hole acts as a cushion which should be as thin as possible. In some cases, successful shots have been made by simply putting the dynamite in a canvas bag.

4. Extreme care should be used in the amount of explosive used in the first shot, for, very often, such a large amount of material is loosened that it is almost impossible to bail out; holes have actually been lost by being overshot. Here again, experienced advice is extremely desirable.

It has been the policy at Madison not to fire shots at a depth less than 200 ft below the casing. This precaution is taken to prevent damage to the casing. In general, shots should be located in the coarser formations because these usually carry the greatest amount of water. During the drilling of a well, it is desirable to record the static water levels each day. It will be found that the static water level rises when certain formations are encountered. It is good policy to shoot in these formations. Occasionally, formations may be encountered in which the static water level lowers. This means that these formations are absorbing water. If such formations are encountered in the lower levels, they should be cased off; if they are found in the upper formations they offer no problem because they will produce water when the water level is drawn down in the well during pumping.

After shooting at a given location, the hole is bailed out, a test pump installed, and a specific capacity test run. Shooting then proceeds at some other location, with customary bailing and testing. It is sometimes desirable to do further shooting in the location which gives the greatest increase after the first shooting. When the shooting is finally completed, the hole is bailed out, the test pump installed, and a 3- or 4-hr test run, after which the pump is removed and the hole again bailed out. This procedure is continued until no sand falls into the hole. After this, a 24-hr run of the test pump is made. If no sand is loosened in this test run, the hole is considered to be completely developed. Although this is an expensive procedure, a well developed in this manner can be used for a longer period before bailing than one developed by less expensive techniques.

Practically every well in the consolidated formations eventually fills par-

tially with sand. The pumping station, therefore, should be designed to permit a well rig to be set over the hole when necessary to bail out the well. It is also desirable to use a large-capacity test pump, preferably one having a capacity 50 per cent greater than that of the permanent pump, as the use of such a pump tends to loosen the sand so that it can be bailed out before the permanent pump is installed.

"An ounce of prevention is worth a pound of cure" applies to the maintenance of wells in that proper construction of the well when drilled will help avoid costly expenditures later.

Large-Diameter Wells

Large-diameter wells should be drilled. This is advisable for three reasons: [1] If a large drive pipe is used, the annular space between the well casing and the drive pipe can be grouted so that no maintenance will be necessary, even if either the casing or drive pipe—or both—corrode or rust through. [2] The selection of a large-size well is also desirable because a pump can be installed with large-diameter bowls which reduce the number of pump stages required. [3] Even if the well is cased by the drive pipe only, it should be large enough so that if it corrodes through, a liner can be installed which will permit the well to be restored to service.

Development

A well should be completely developed at the time it is drilled. This means that the original well should be drilled to the maximum depth necessary to completely develop the water bearing formations. In Madison, the wells are drilled to the pre-Cambrian rock or granite so that all of the water in the sandstone formations will be available. Before the well driller leaves the job, tests should be run and, if the quantity of water is not as great as desired, the well should be shot and bailed out at once.

Pumphouse

The pumphouse should be constructed in such a manner that the well rig can be located over the hole without disturbing the building. A large percentage of wells require periodic bailing and other maintenance which involve the use of a well rig. In the selection of pumping equipment, considerable maintenance can be eliminated if the deep-well pump is required to pump the water to the surface of the ground only, with further work done by booster pumps. This will mean that there will be less work required in the hole and, therefore, a smaller number of stages. Incidentally, the combination of a deep-well pump and a booster pump ordinarily results in higher efficiency than if the deep-well pump is required to pump directly from the well into the distribution system or industrial plant.

Repairs

Some repairs are quite common, such as that needed in a well which had been in service approximately 20 years and which had showed a progressive reduction in specific capacity. When the pump was pulled, there was no evidence to indicate any loss of efficiency in it, but the well was found to have filled up with the sand to about 200 ft from the bottom. The well was bailed out and the original specific capacity obtained. During the pumping test, however, the specific gravity gradually increased until it was about 20–25 per cent greater than the original capacity. When the pump was re-

moved it was found that there was a soft spot in the sandstone formation which had caused the lower 50 ft of the well to fill. It was quite clear that the lower 50 ft of the well was actually absorbing water so that it never bailed out. The well is still producing water with a specific capacity higher than when it was drilled—about 30 years ago.

One of the most interesting well repair jobs occurred at the main station well. This well had a 30-in. drive pipe and a 24-in. casing, and was pumped by airlift. It originally produced approximately 3,000 gpm with a drawdown of about 75 ft. After this well had been in operation 5 or 6 years, the specific capacity began to drop off and it was found that sand was being pumped with the water. The well was bailed out and no difficulty was encountered for another 5 years, when the well began to produce large quantities of sand. Again it was bailed out and the pump replaced, but a large quantity of sand continued to be pumped up with the water. Originally, the capacity of the sand basin associated with the clear well was about 40 cu yd and this had to be cleaned roughly every year. Before the repair was made, 40 cu yd of sand was being pumped up in approximately a month or 6 weeks. Obviously, the cost of cleaning the sand basin this often was prohibitive. The rock formations encountered during the drilling were comparatively soft and no shooting was done. During the 10 years in which this well was used, however, the water rushing toward the well had apparently dissolved enough of the cementing material so that what was originally sandstone formation had become simply sand. It was clear that if this well were to be of further service the sand pumping would have to be eliminated.

A study of the problem indicated that the installation of a suitable screen, with gravel packing between the screen and the open hole, would be necessary. In working out the details, several factors had to be considered. First, it was clear that if the screen was installed and the gravel packed back of it, it could never be removed, and the life of the well would be dependent upon the life of the screen. The screen finally selected for this purpose was made of a copper-silicon alloy,* and its life was estimated to be at least 25 years. The screen was constructed of pipe, 12 in. in diameter, with slots 1.5 in. in length and $\frac{3}{16}$ in. in width, with staggered spacing.

It was also recognized that the gravel which was to be placed around the screen might eventually clog it, requiring acid treatment. For this reason, a granite gravel was selected, because this would not be affected by acid as would limestone or sandstone gravel. The gravel used was $\frac{1}{2} \times \frac{1}{4}$ in., well rounded and graded. This size was used in order that it would not pass throught a $\frac{3}{16}$-in. slot but would flow readily for proper placing.

The depth of the hole to be developed was 720 ft. It was decided to support the screen on the end of the eduction pipe. Inasmuch as this was 450 ft long, 270 ft of screen was ordered. The opening at the lower end of the bottom length of the screen was closed with a welded-on flat plate. This plate rested on the bottom of the hole which had been filled to the proper point to form a cushion. The entire weight of the screen, however, was carried by the eduction pipe, as a clamp, attached to the top of the eduction pipe, rested on the well casing.

* Everdur, a product of the American Brass Co., Waterbury, Conn.

The screen was welded with a special jig, to insure alignment. The welder tacked the two pieces of screen and then removed the jig to complete the welding. The screen was lowered with a well rig. The connection between the 14-in. eduction pipe and the screen was made by welding a 12-in. pipe coupling inside the lower end of the 14-in. pipe and inserting in it a 12-in. nipple which was welded to the top of the screen.

It was decided to feed the gravel, which was to surround the screen, through the eduction pipe and two slots 4 × 16 in. were cut in the pipe near its bottom. To prevent the gravel from working inside the screen, a cast-iron plug was screwed into the 12-in. coupling before the 12-in. nipple was inserted. This plug was subsequently drilled out when the gravel packing back of the screen was completed.

A heavy sash weight on the end of a piano wire was used as a plumb to ascertain the depth of the hole filled with a measured quantity of gravel. It was also important to be sure that the gravel was not bridging but was actually reaching the proper location back of the screen. In order to have a definite measurement of the quantity of gravel that was being poured into the eduction pipe, 50-gal oil drums, reinforced with flat steel and provided with a bail, were used. In view of the fact that 150 cu yd of sand had been pumped out in the 4 months immediately preceding the repair and that, before that time, at least 50 cu yd had been removed from the sand basin at various times, it was felt that at least 200 cu yd of gravel would be required. Only about 100 cu yd was necessary, however. This was a result of the fact that the sand had washed out in thin layers of only 12–18 in. in thickness. The openings went back into the sandstone formation probably 10–20 ft, but there were no large open spaces requiring a large amount of gravel at any one point. It was quite clear that gravel could not be forced back more than 3 or 4 ft because of the thinness of the soft formations. After the gravel had filled to the top of the screen, it was decided to fill the annular space between the eduction pipe and the well casing to provide an additional head on the gravel with which to force it back into the openings. To do this, it was necessary to cover the 4 × 16-in. slots with a 12-in. pipe, about 8 in long, which fitted very nicely in the 14-in. eduction pipe. This pipe was lowered into the eduction pipe until it hit the nipple. After the slots had been closed, the gravel was poured into the annular space until it was filled. The airlift equipment was then reinstalled and the well pumped. Pumping was started and stopped several times because the starting and stopping action causes considerable vibration which would tend to force the gravel further back into the openings. In this instance, however, the gravel lowered only about 8 ft in the annular space. The well was then put back into service.

Results

The original pumping rate was 3,000 gpm, and when the well was first put back into service, it was pumped at 2,500 gpm, with no evidence of sand. The rate was gradually increased until a small quantity of sand began to come up—at 2,800 gpm. When the well was put into service permanently in November 1944, it was pumped at a rate of 2,700 gpm. The cost was approximately $10,000.

The airlift equipment has since been removed and an electric pump installed because of its lower pumping cost. In recent years, the pumping rate has been

reduced because sand has appeared, but, despite this the investment has proved to be excellent having saved the well at about one-third the cost of a new one of the same capacity.

"Iron Bacteria"

About 2 years ago, water from one of the wells displayed rusted particles and a very high chlorine demand. The conclusion was that *Crenothrix,* or "iron bacteria," were present

Several gallons of sodium hypochlorite solution * were poured into the well between the pump column and the well casing and left overnight. The next day a sample of the well water showed no chlorine residual. More chlorine was added until a heavy chlorine residual was obtained. The pump was then started and stopped a number of times, allowing just enough time to permit the water to rise to the surface on the expectation that heavily chlorinated water would recede into the iron-bearing formation and kill the iron growth there.

The expectation was correct and the cure sufficiently complete so that, with very heavy chlorine dosage applied daily and a heavy chlorine treatment in the well itself about once a year, the well produces satisfactory water.

Many years ago marsh gas odor was detected in the water from a well being pumped directly into the mains with a deep-well pump. The gas was eliminated by constructing an adjacent reservoir with an aerating house, by the installation of a high-service pump to deliver the water to the system, and by having the deep well pump deliver to the reservoir.

Illinois—*Harman F. Smith and Robert T. Sasman*

A paper presented by Harman F. Smith, Head, Eng. Subdivision, and Robert T. Sasman, Assoc. Engr., of the Illinois State Water Survey, Urbana, Ill.

During the past 70 to 80 years, the use of ground water in Illinois has developed on an immense scale. In addition to the increasing development of large municipal and industrial supplies, numerous smaller communities are installing public water supplies and rural homes are coming to rely on private water distribution systems in place of the "old oaken bucket." The number of Illinois municipalities having public ground water supplies has increased from approximately 300 in 1925 to 625 in 1957. The increasing installation of dishwashers, automatic and conventional washing machines, food waste disposers, and other water-requiring appliances is resulting in more water being used in homes. Industries are demanding large quantities of water for cooling and air-conditioning purposes, and increasing use is being made of water for irrigation and other agricultural requirements. Ground water used in Illinois during 1956 was more than 600 mgd.

In Illinois cities of 15,000 to 50,000 population, residential water use has increased 15 gpcd during the past 15 years. Present indications are that, in these same communities, the residential de-

* Product used was B-K liquid hypochlorite, manufactured by Pennsylvania Mfg. Co., Philadelphia, Pa.

mand may increase as much as 20 gpcd by 1970.

Advancement of Well Construction

In order to keep pace with this growing demand for ground water, well construction has developed considerably. Dug wells, formerly prominent throughout the state, now usually receive consideration only in areas where ground water resources are limited and where only very small quantities of water are needed. Seventy to 80 years ago, drilled wells finished in unconsolidated sand and gravel deposits were of tubular design, with only an open bottom or slotted casing to allow water to enter the well. Since 1900, screened wells have continually increased in importance. More recently, large-diameter gravel-packed wells, porous-concrete screen wells, and perforated-concrete pipe wells have become increasingly popular.

Bedrock wells were commonly finished 6–8 in. in diameter in the early 1900's. Wells of recent design are often finished 16–20 in. in diameter. These large well bores not only allow water to enter at a lower velocity, but also permit the installation of large-size pumps required to raise large volumes of water from great depths, as in the deep sandstone in northeastern Illinois.

In line with increased water use and improved drilling techniques, improved methods of well rehabilitation are helping to increase the service life of wells after they are drilled. Wells of diminished capacity can often be returned to near the original productivity by one of several rehabilitation methods. Wells finished in unconsolidated formations often respond favorably to treatment by polyphosphate, acid, or pump surging. Using hydrochloric acid in limestone wells and shooting sandstone wells with explosives often increases production from bedrock aquifers.

Areas of Development

Although well construction and rehabilitation techniques have steadily advanced, the investigation of ground water resources throughout the state must continue to play a significant role in the development of adequate water supplies. Not only state agencies, but municipalities, consulting engineers, well drillers, and well owners can help meet the growing need for detailed information. Even the best constructed well will not produce water from a poor aquifer.

Illinois has several good ground water producing areas. There are many areas in the state where water in large quantities is being obtained from shallow wells finished in the glacial drift. The wells are usually less than 300 ft deep, and many finished in river flood plains such as the Mississippi, Illinois, and Wabash rivers, are no more than 100 ft deep. Comparatively large quantities of water are being secured from sand and gravel wells in the east-central part of the state and in much of the flood plains of the Mississippi, Illinois, Wabash, and Kaskaskia rivers.

In a much smaller part of the state, ground water is secured from the limestone and dolomite bedrock underlying the unconsolidated materials. Large quantities of water are being secured from urban areas surrounding Chicago and from a few isolated areas where considerable crevicing was encountered. These wells are seldom more than 500 ft deep and, at several locations, their depths are less than 200 ft.

Throughout northern Illinois it is possible to secure usable ground water in large quantities from wells drilled deep into bedrock. The depth of these

wells is rarely less than 1,000 ft, with many of them drilled to depths of nearly 2,000 ft. The deepest active well is at Peru and has a depth of 2,665 ft. Lesser quantities are being secured from wells in several isolated areas.

Summary

For the most part, Illinois ground water resources have not been overtaxed, but, at some places, where large concentrations of population have relied on ground water, problems are appearing. These local problems have led many to suspect that ground water resources throughout the state are failing.

It appears that there are many areas of the state where additional quantities of ground water can be secured. The state's ground water resource can be enjoyed for many years to come if its development is planned wisely. This planning should, of course, be on a long-term basis with much consideration given to conservation. To think of conservation, however, as hoarding or unnecessary restriction of use is neither necessary nor wise.

Kalamazoo, Mich.—*Paul Sabo*

A paper presented by Paul Sabo, in charge of drilling for the City of Kalamazoo Water Utility, Kalamazoo, Mich.

There was a time, when this country was young, when communities were small and populations thin, that a water well was considered nothing more than a convenient hole in the ground. In those days, when the standard of living was not anywhere near what it is today, water was considered to be very much like religion—free to everyone, and only the piper to be paid.

Today, water has become a product—made one by the people's demands that it be available in unlimited quantity. It has become a product of which the standard of living now demands that it always be cold enough, clear enough, and even wet enough to suit the most whimsical among us.

If one operates a private water company or a municipal one operating on a profit-and-loss basis, he will realize that water is something which people now consider as any other product that they buy and for which they pay. Both from the standpoint of price and quality, therefore, it is in competition with every other product bought.

A well, then, is no longer just a convenient hole in the ground; it must be considered as the source of supply for the product to be produced, distributed, and sold at a profit—at a price that, for all practical purposes, is set by the consumers.

The well, therefore, must be a highly efficient part of the overall operation of the business. To be so it must be constructed in the most suitable area available, and developed, not just as a water well, but as a production well.

If one is to keep pace with the expansion, or even the year-to-year development of a community, he cannot afford not to be active in the real-estate business. He must be active, even if only to the degree of continually securing options on likely well sites, and exercising these options by surveys, by resistance methods, and by test wells. In addition, geologists and hydrologists

have made great strides in mapping underground formations and water movement and one should not be guilty of ignoring these findings.

A dry well or a bad well is just about as costly to construct as a good one. In other words, the locations of production wells are based on knowledge of the area, derived from early exploration work that indicates, beyond much doubt, that water is available in a quantity and of a quality that is profitable to produce, distribute, and sell. Furthermore, between the time of exploration and construction it may have been possible to guide the expansion of the distribution system so that the size and location of the grid make costly feeder mains virtually unnecessary.

The development of the production well into a long-time efficiently producing unit is perhaps the least understood, the most abused, and yet the most important factor in the construction of a well.

Before any well can be considered a success, it must pass all state and local requirements of isolation, depth, purity, and other, similar points. It must also be constructed in a location that will not disrupt the production of any existing well. It's construction should be of proper materials employed in the best workmanlike manner possible, and it should furnish a suitable amount of potable water at the greatest possible efficiency. Finally, it must maintain efficiency year after year with a minimum of maintenance.

Sampling of Strata

In constructing or maintaining a well it must be kept in mind that the capacity of the drift formation in which the well is situated is governed by the texture and depth of the water-bearing strata available, in conjunction with the recharge rate and area. Samples from test wells, therefore, should be carefully taken with respect to recording the true texture and true depth of the strata encountered. These data will determine the size, number, and type of wells to construct; they are also useful for maintenance work.

If the formation is of very coarse gravel, a preslotted concrete casing or a slotted steel casing will prove satisfactory. The use of well screens, however, seems to have become generally more popular because the general lowering of the water table may eliminate the possibility of exploitation of coarse gravel veins. Well screens utilize sand veins that are too fine for slotted casings, and, in general, add to the overall efficiency of the well.

In Kalamazoo, when exploring a promising well site with test wells, 12-in. casings are used. The cost is not appreciably greater than 6-in. casing and, if the well proves productive, the casing for the production well has already been installed.

Development

The task of well cleaning or developing involves a few basic facts, good judgment, and, as a rule, considerable time. Time is usually a point governed by the amount of money available. Too often, the amount of water produced is the only factor considered. The savings in pumping and future cleaning costs, and the value of a dependable supply are usually underestimated. Particularly on new wells, the extra time spent on developing pays dividends in years of trouble-free service, for when a well begins to fail, far more may be spent to save the investment than a good job of developing would have cost originally.

The methods of developing are many and varied, but with one purpose: to

remove the clays, silts, and fine sand surrounding the screen. Unless chemical changes have taken place, the developing of a new well or an old well is much the same. The method depends upon the area to be cleaned or developed. The surge block or compressed air constitute perhaps the most effective means. With these, a back-and-forth surging or washing action is created, which loosens the formation and carries fine particles into the screen from which they must be removed.

Overpumping seems to be of little value unless a very high lift is encountered, because no backwashing action takes place. If facilities for creating a surging action are lacking, however, overpumping is the best method of bridging a sand-pumping well. High-pressure jetting and controlled explosive charges are fairly new methods, but hold promise of good results.

Acids and various compounds such as phosphates and detergents should not be considered as a complete treatment in themselves, but rather as an aid to the surging methods. This is especially true in the cleaning of old wells where incrustations or growth may have formed inside or outside the screen. State or local health departments should be consulted for approval before using chemical compounds or acids.

The amount of developing suitable for a new well depends on the formation surrounding the screen. The more uniform the sands or gravels, the less work needed. A mixture of coarse gravels through fine silt requires much more time, especially if much clay is present. This kind of dense, compact formation with low porosity and high resistance to water movement requires that a greater proportion of material be removed.

For example, in a uniform coarse sand of which 90 per cent is retained on a 1-mm screen, 10 per cent passes and must be removed. In a mixture of, which 60 per cent is retained on a 2-mm screen, 40 per cent is fines that need to be removed (based on a 60 per cent retention). Thus, for each cubic foot of soil to be cleaned, the latter will give up four times as much fine material as the first. It is seen then, that around a large screen, many cubic feet of soil are affected without penetrating very far into the formation.

The amount of water that will pass through a soil depends on its grading. The ideal would be a uniform, coarse clean gravel of rounded stones. Here the voids would be fairly large and would offer little resistance to moving water. As the gravel size decreases, the voids decrease in size and the resistance increases. In a mixture of coarse and fine, the voids become even smaller because the smaller particles lodge between the larger, further increasing the resistance.

The faster water moves, the larger the particles it will carry; as its velocity decreases it drops more and more of its load. Thus, the greater the surging action, the greater the distance out from the screen the area which will be cleaned.

A great amount of water will move slowly through a large area and quickly through a small one. As water moves toward a well screen from all sides it picks up speed because of the ever smaller area through which it is passing. In a properly developed well, the enlarged openings in the coarser materials surrounding the screen tend to keep the velocity of the water down to a point where the moving water will not carry any sand or silt which might eventually pack tight against the screen.

It is then easy to see that a well in mixed soil would require much more time to develop than one in a uni-

form coarse sand. No set rule can be made to cover the development of every type of formation; each well must be treated according to its individual characteristics.

Cleaning

The medium portable percussion well rig will usually handle wells up to 12 in.; the large rigs, wells up to about 20 in. With wells over 20 in. the forces encountered are too great for this type of equipment and compressed air is preferable.

The cleaning process should be started slowly. The rig should be set on a short stroke, and run at low speed. The surge block should be made so that it can be kept full size.

A valve arrangement in the surge block will improve its use by allowing a head to build up in the well. If the water is within the limits of a suction pump, the removal of water while surging will speed the work by reducing clay and fine sands. As the cleaning progresses, the speed of the rig is increased until the limit of the surge is reached—that is, to the point where the weight of the tool string will not keep the cable tight. The stroke is then lengthened, and this operation is repeated until the limit of the rig is reached. Sand must be removed from the screen at intervals with a sand pump, and swabbing the inside of the screen itself when surging is completed may also help.

It must be remembered that the amount of water removed by the longest stroke of the rig is very little compared to the screen area; the travel being only a fraction of an inch. For example, a 12-in. well with a 20-ft wire-wound screen will have approximately 60 sq ft of total area, of which 30–60 per cent will be open. A well rig with a 3-ft stroke will discharge approximately 17 gal of water, which will have 20–36 sq ft in which to travel.

The greatest speed at which the rig will surge is dependent on the weight of the tool string. It is the weight of the tool string that causes the downward stroke, or the outward forcing of the water, while the power of the rig lifts the column of water, drawing additional water into the screen. By operating the well rig with hand control and by running the surge block the full length of the well, water can usually be brought into the screen at a greater rate than it can be forced out.

It is much more difficult to control surging with compressed air than with a well rig. When using this method, the well is fitted with an airlift pumping line, and an air line into the well which is then sealed at the top. An air compressor of suitable size, and an air storage tank with several times the volume of the well is desirable.

The downward push of the column of water is caused by forcing air into the well. An air gage at the well will show how much pressure is exerted on the water but not necessarily how far the water has been pushed back. The air is then released from the well and the water is allowed to rise to its normal static level. This single cycle—one surge—may take several minutes compared to the fifteen or twenty surges per minute made with a well rig. At first, only a few pounds of air pressure is applied to the well, but this is increased as the cleaning progresses. The sand is removed through the air lift. Air surging, in contrast to surging with a well rig, is by far the slower of the two operations.

Operations at Kalamazoo

In 1932, two gravel-packed wells were installed at Kalamazoo. Each had

a 72-in. outer casing, and 40-in. inner casings. Both had to be cleaned within 5 years after construction. In 1944, five 12-in. wells were installed with iron screens. In 1949, one was pulled and redrilled and the other four were fitted with brass screens. In 1945, nine 12-in. wells were installed with iron screens. Since then, three of this group have been fitted with brass screens and several of the others have been cleaned. In 1947, the first two wells were installed using water department equipment and personnel, and many have been installed in the same way since then. In all these wells development has been stressed, and none has yet required maintenance.

Records

No discussion of the construction and maintenance of wells should ignore mention of the vital importance of adequate well records. These records can have several uses, one of which would be in the making of a quick survey of a well field. For example, if the length of the screen of each well is accurately recorded, then measuring the gallons per foot of drawdown of the well and dividing this figure by the length of the screen in feet will give an indication of the transmissability of the soil around the screen—the larger the figure, the greater the transmissability.

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Construction Equipment for Small Water Utilities

William K. Foerster

A paper presented on April 26, 1957, at the California Section Meeting, Santa Monica, Calif., by William K. Foerster, Gen. Mgr., San Gabriel County Water Dist., San Gabriel, Calif.

THIS article will deal with water utilities which do between $50,000 and $100,000 worth of construction work per year, including in this sum all material, pavement repair, and labor costs. Almost any organization that does no more work than this, is usually confronted with the question of whether to do the work itself or contract it. If the idle time of standby labor that is on the payroll can be used to do various jobs of 500 ft or more, and if there is no unavoidable waste, it will pay the utility to do its own work—if there is enough rent-free fundamental construction equipment on hand. Such equipment would consist of the following: one flat-bed dump truck, one 105-cu ft capacity air compressor with two heavy pavement breakers and 50 ft of hose with each breaker, one ⅝-yard skip loader, two ditch pumps with no more than 12 ft of suction hose per pump, one electric generator for two floodlights, one 3-ton crane, and one flat-bed truck with a 2-ton capacity. Pickup trucks used for routine work are not included, nor are a ditching machine and a large tapping machine. If a tapping machine cannot be rented nearby, however, it will pay to have one on hand. Labor will consist of existing skilled personnel plus local men who are usually not skilled in this work.

The above equipment constitutes an original investment of approximately $22,000 and must be kept in good repair because there is not enough standby equipment for use in the event of a breakdown.

Dump Truck

The dump truck is the piece of equipment that will usually save more time and expense than any of the others. Organizations such as those under discussion do not have large working crews, and the idle-time charge for rented trucks, plus time spent waiting for trucks to get to the job, soon amounts to the price of a new truck. Idle-time charges plus waiting time for rented trucks can be $1,200 per year. Driving or riding time is another cost factor, because most utilities have several dumping grounds (for broken street pavement and dirt) the locations of which are unfamiliar to the driver of the rented truck. A local employee must, therefore, be taken from the work to act as a guide for the driver.

Dump trucks should not be used for hauling 10-in. (or larger) cast-iron pipe. In rolling it off, the pipe eventually comes to rest on one side of the truck, throwing the dumping mechanism out of line. The flat-bed truck should be used for hauling rolling

loads and should be equipped with tool boxes for small tools. This truck should be on the construction job at all times.

Compressor

The air compressor and pavement breakers are also expensive to rent. The price of an air compressor does not warrant rental, unless it can be used most of the 8-hr shift. When used on small jobs with a small crew, the compressor is idle a considerable part of the time. The idle-time charge added to running-time charge will show a triple or better cost against actual use time. The compressor is also used in routine service installation work in paved areas. Two breakers with 50 ft of hose for each breaker is desirable, since two men can work on each side of the ditch in breaking pavement. If more than 50 ft of hose is used, traffic will run over a good part of it, and there will be some dragging and cutting of it on the pavement. Long hose continually kinks, and the kink is usually jerked loose, which tends to break the hose braids. Small tools, such as air hammers and air spades, are useful adjuncts of the compressor, but are not essential. Sometimes the smaller tools are a handicap in that some of the men, once seeing them used, assume that the work cannot be done again without them.

Skip Loader

The skip loader is the most expensive of all the equipment and has the highest cost of maintenance because of overloading and speeding. It is good policy to buy a $\frac{3}{4}$-yard loader and have a $\frac{5}{8}$-yard bucket installed. Unless the supervisor insists that it not be used as a truck, the men will use it for such jobs as carrying oxygen tanks or large valves in the dipper from warehouse to job site. During such times, the loader is run at full speed for a mile or so, and the low speed gears cannot withstand such abuse. Used as a crane for loading trucks with 1,000-lb articles, for backfilling, for loading dirt or broken pavement onto a truck, and as a substitute for a crane in setting fittings in the ditch, the skip loader is practically unexcelled. Repair bills of $500 are normal for this machine unless it is well cared for. It is so fast and easily handled in narrow streets, however, that it makes up for its cost in time and labor saved.

Ditch Pump

Every water utility should have at least two ditch pumps in good condition at all times. The length of suction hose should not be more than that needed for a 7-ft deep trench, unless the average depth of work is more than that. If the hose is too long, it will be mistreated in the same way as the air hose—and this hose costs approximately $5 per foot. The hose can be patched with expensive couplings only, and the couplings usually leak after a few hours of use. This pump saves valuable time on leaks or in tying to existing lines that are being drained. Time is more important in this operation, because some consumers will be deprived of water during the work period. The pump is also a good piece of public relations equipment. When it is running, even though pumping no water, it is so noisy that it gives the impression that all are working hard and doing all they can. The pump should be checked for repairs after use for 20 hr. Rocks and sticks seem to accumulate around the propeller and, although the machine will work with the debris in the casing, after it has

been idle for a few days, the debris will break the propeller or cause the pump to lose suction.

Generator

A generator for two floodlights is another light piece of equipment that speeds work. This is seldom used outside of emergency work. Crews will spend 25 per cent of their time adjusting truck lights and flashlights only to have truck batterys go dead and flashlights fall into the mud. Two floodlights, with 50 ft of extension cord for each light, speeds work and prevents the loss of small tools in the ditch.

Ditcher

The price of a ditching machine does not warrant buying one for the amount of work small utilities do. In 2 months $60,000 worth of work is usually accomplished in paved areas; this leaves the ditching machine investment idle for 10 months. All the other equipment mentioned in this article is useful on routine work. In addition, because few construction men are experienced operators of ditching machines, maintenance costs would be prohibitive.

Costs, over a 3-year period—1954 through 1956—with one organization that did $175,000 worth of work, were as follows. Idle time, 93 hr; working time, 253 hr; rental of a ditching machine, including moving on and off the job, $18.75 per working hour. Total cost was less than $4,700 for the 3-year period. The pipe installed was 4- to 8-in. size.

Crane

A crane that will handle 3 tons is a piece of equipment that will do more for the morale of the men working than any other equipment. It is not needed for 4- and 6-in. pipe, as that size range may be installed by hand labor. Turning of the pipe to place the bell ends properly, and dragging of pipe into position, all tend to make the crew feel it is being overworked. Besides, lowering a pipe into a ditch with ropes and hand labor usually results in breaking one joint per day, plus a couple of sewer or gas connections, which are always in the excavated ditch. The crane should be on pneumatic tires, as solid rubber tires cut shallow pavement and are also hard to handle on a soft road bed. The crane should also have at least 180-deg turning capacity, and a ball-bearing swivel safety hook. This type of hook costs approximately $50, but it avoids twisting of cable and makes the turning of the pipe, while lifting, very easy.

Maintenance

The problem of maintenance should be considered as important as the buying of equipment for small projects. When equipment is idle for a few weeks between jobs, the usual procedure is to omit checking it for oil and grease before it is needed again. If an emergency arises, the equipment is usually not oiled or greased before work starts. This can be prevented by having particular days set aside for greasing equipment, whether in use or not. This should be in addition to equipment checks made while working.

Installation and Maintenance of Valves and Hydrants at Wilmette, Ill.

Leonard F. Lindeen

A paper presented on Mar. 22, 1957, at the Illinois Section Meeting, Chicago, Ill., by Leonard F. Lindeen, Foreman, Water & Sewer Dept., Wilmette, Ill.

THE village of Wilmette, Ill., is a purely residential community located on the west shore of Lake Michigan just north of Evanston; it has no industries and only such commercial establishments as are needed to supply its own citizens. A small part of the present village was incorporated in 1872, and by means of later annexations of surrounding land, was brought to its present area of approximately 5.28 square miles in 1926. Future expansion will be extremely limited as it is almost completely surrounded by neighboring municipalities. The village is approximately 1 mile wide and 5 miles long, and the present population is approximately 24,000. The water works facilities are located on the shore of Lake Michigan at the eastern extremity of the 5-mile strip.

For 20 years after incorporation, Wilmette's citizens, who were, for the most part, well-to-do business men and industrialists from Chicago, struggled with individual wells for water supply. In 1893, a start was made on a water distribution system as more than 25 miles of 6- and 8-in. cast-iron mains were installed. The population at that time approximated 1,500; the water was purchased from Evanston. Today, Wilmette is extremely grateful to those early planners who installed no mains smaller than 6 in., who provided an auxiliary valve on every hydrant, and who placed most of the line valves in vaults rather than in boxes. Practically all of the water mains, valves, and hydrants then installed are still in service, and, for the most part, in excellent condition. Because all of the hydrants and most of the line valves chosen at that time were of a type which has proved best for use under the particular conditions, maintenance problems have been greatly minimized.

System Growth

The growth of the distribution system was slow and steady until the mid-1920's when the adjoining village of Grosse Point, together with a large tract of farm land to the west of that village, was annexed, thereby extending the boundaries to their present limits. This great increase of area necessitated the construction of more than 18 miles of 6-, 8-, and 12-in. water mains and, because of exceedingly low pressures in the higher parts of Wilmette, an elevated storage tank floating on the system, of 400,000-gal capacity.

In 1934 Wilmette completed the construction of its own filtration and treatment plant, as well as almost 2 miles of 24-in. feeder mains, which, 4 years later, led to a request for water from

Fig. 1. Standpipe of 4-mil gal Capacity

The standpipe is approximately 115 ft high, and has an 80 ft ID. The building to the left is the superstructure of the altitude valve vault.

the neighboring village of Glenview, whose wells were failing. In 1930 Glenview had been a little farming community of 1,900 people, but it was beginning to feel the increasing demand on the part of Chicago's people for suburban homes.

By 1949 the growth of both Wilmette and Glenview reached such proportions that it was necessary that Wilmette once again add more than 5½ miles of 6-, 8-, and 12-in. mains to its distribution system. A few years later water shortages began to occur during the summer seasons as a result of the rapidly increasing sprinkling and air-conditioning system loads. Sprinkling regulations were enacted and strictly enforced, and the Wilmette water works, with its rated capacity of 6 mgd, was frequently filtering, treating, and pumping more than 9 mgd with the consequent strain upon men and equipment.

In late 1955 a general expansion of the entire system was begun. In the fall of 1956 a 4 mil gal standpipe was completed and placed in service near the western limits of the village (Fig. 1). Almost 5 miles of 24-in. prestressed concrete pressure pipe has been installed, providing a full 24-in. feeder main from the water works at the east end of the system to the standpipe near the west end. Part of the procedure of installing a valve on this main is shown in Fig. 2 and 3. This transmission main is cross connected at intervals throughout its length to the larger mains in the gridiron, thereby providing excellent balance throughout the system. The water plant is being enlarged from its present capacity of 6 mgd to 15 mgd; this plant will be completed in the summer of 1957. A booster pumping station is being constructed at the standpipe and larger connections, together with improved metering facilities, are being provided for the supply to Glenview.

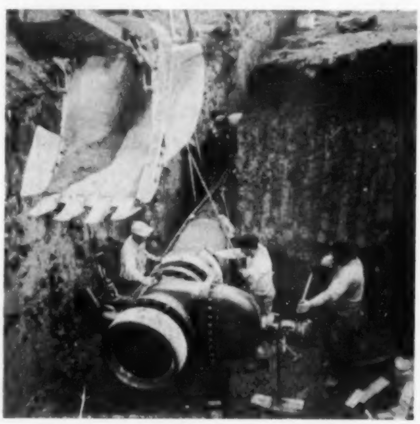

Fig. 2. Installation of 24-in. Valve

The valve, pushed home on a 24-in. prestressed concrete pressure pipe, is being held in place by the bucket of the backhoe.

Since Jan. 1, 1950, the Wilmette distribution system has been increased by 14.7 miles of water mains, 83 line valves in vaults, and 86 fire hydrants with auxiliary valves in boxes. Most of these facilities have been installed by subdividers.

As of Mar. 1, 1957, the Wilmette distribution system consisted of 83.1 miles of water mains, 662 line valves (more than 90 per cent in vaults), 730 fire hydrants with auxiliary valves in boxes, one 400,000-gal elevated tank, and one 4,000,000-gal standpipe. This system serves the combined populations of Wilmette, Glenview, and the US Naval Air Base at Glenview—a total of approximately 39,200 people. Should failure occur at the water plant, there are five mutual aid connections provided to the distribution systems of three adjoining municipalities—Evanston, Kenilworth, and Winnetka—each of which has its own independent water plant and distribution system.

System Organization

The growth of the distribution system was not accompanied by a comparable growth in organization and maintenance. For many years there was no water department as such and, for the most part, the distribution system received little attention save in emergencies. At such times, repairs were made by laborers from the street department under the casual supervision of the street department foreman. For some years the water department, even after it had become a separate unit functioning under the supervision of the superintendent of public works, had to borrow labor from the street department, and, while this group usually contained at least one man who had had previous experience in water main work, there were no specially trained men, so that there could be no planned and sustained maintenance program.

A reorganization of the water department was made under the present superintendent of public works who combined it with a sewer department, and assigned specially selected men to water and sewer work only. As a result, it has been possible to train these men in the particular skills required for proper maintenance work, and a sustained maintenance program has been planned and instituted.

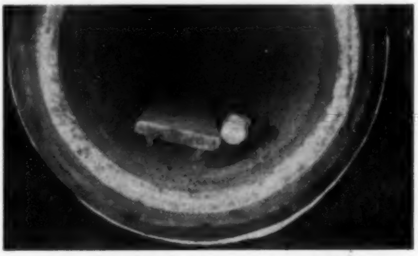

Fig. 3. Inspecting a 24-in. Main

By lying on this 4 × 10-in. plank mounted on roller skates, it is possible for a man to propel himself through the pipe and thus accomplish various tasks such as inspecting the pipe, and mortaring the joints. A flashlight and a rag lie next to the dolly.

There are definite advantages in a combined water and sewer department, as much of the maintenance work on both is closely allied. The men who rod, clean, and flush the sewers, for example, are also responsible for maintaining the hydrants, so that there is no abuse of hydrants by the sewer department. It is not at all unusual that one man completely dismantles a hydrant which has been found faulty during the progress of a sewer job, while the rest of the crew continues the cleaning and flushing of the sewer using the next hydrant available.

As has already been stated, Wilmette long ago standardized on the two types of valves which were found in the system for, although these have been greatly improved in the past 50 years, they have remained basically the same and they can, for the most part, be repaired. The older parts of the system contain valves which open to the left and valves opening to the right. Occasionally valves are found on which no manufacturer is designated. Whenever one of these valves is found to be faulty, little time is wasted in efforts to repair it. It is more economical to have a new valve cut in under pressure and less inconvenient, in that no shutdown of the main is required.

System Records

Good records constitute a major item in any maintenance program. Wilmette maintains two large atlases which show in detail the dedicated streets, water mains, valves, and hydrants. Valves and hydrants are shown in relation to the nearest property lines of the dedicated streets. The number of turns required to operate the valve is indicated as well as the direction of turn. Although it must be admitted that these are often in error, some 85 per cent of these notations are correct, and the records are constantly being checked and rectified. In each shutdown made necessary because of a break in the main, a new connection, or any other reason, careful and detailed records of operation are made. The exact location of the valve is noted, the direction and number of turns, the ease or difficulty of operation, the apparent condition of the valve, and recommendations for servicing. These notes are immediately compared with the corresponding notes in the atlases, and wherever the atlases are in error, the correction is made. Although this method of correcting records is slow compared to a regular valve operating program, it does have three distinct advantages: [1] practically no extra cost is involved; [2] only a few valves are involved on each occasion, which permits the foreman personally to check the records; and [3] there are no irate citizens to placate—citizens who while finding no difficulty in understanding that it is necessary to deprive them temporarily of water when a geyser is apparent in the street, fail to comprehend that the same temporary deprivation for purposes of routine operation can have any basis save that of personal spite.

In addition to the atlases, distribution system maps with a scale of 600 ft to the inch showing all water mains, valves, and hydrants are kept, as well as smaller sectional maps which also indicate the direction of turn. These maps are carried at all times by the foreman in his car, and copies are furnished to the workmen as required, with the valves to be operated clearly checked in red pencil.

Valve Installation and Inspection

Little needs be said about the actual installation of line valves. In Wilmette they are so spaced in the system that not more than 800 ft of main needs be shutdown for any single break. For the past 20 years, standards have required that line valves open to the left, or counterclockwise, and hydrants and auxiliary valves open to the right, or clockwise. This greatly simplifies records in the newer parts of the system and, whenever a line valve in the older section must be replaced, a left-hand valve is installed.

Mechanical joint valves are now used exclusively in the distribution system, except in large transmission mains, where flanged valves are installed. In the rare occurrence where a lead joint is mandatory, a rubber ring is used instead of the unsanitary jute. Virgin pig lead only is permitted in such joints; the lead must be at least 2¼ in. in depth, and the joint must be made in one continuous pour. In the event of any difficulty encountered in making the joint, the lead must be removed by melting, the rubber ring removed and inspected, and the entire joint repoured.

All line valves must be installed in vaults; 6- and 8-in. valves require a 48-in. ID and 12-in. valves a 60-in. ID vault. The vaults are constructed of preformed concrete blocks with a cone opening of 24 in., a cast-iron frame and cover; they must be plastered inside and outside with mortar. The base, which may be poured or constructed with preformed slabs, must rest on a 3-in. tamped sand cushion, which in turn rests upon solid, undisturbed earth. There must be at least 8 in. between the base of the valve and the top of the slab to allow sufficient room for future maintenance. The weight of the valve must be supported by means of a concrete block or a poured concrete pier. The connection of a drain from the vault to a sewer is not permitted; in larger vaults a sump is constructed to facilitate possible future pumping.

All valves are inspected before being lowered into the trench for evidence of mishandling and for proper marking for direction of turn on the operating nut. An incident that occurred a few years ago proved that it is also necessary actually to open and close the valve before installing it on the pipeline. On a subdivision, three or four 6-in. gate valves which met Wilmette standard had been inspected and installed, but when it came time to fill the main for the pressure test it was found that, while these valves were all clearly marked left to open, they actually had to be turned in a clockwise manner. As the valves were already installed and the vaults constructed around them, and as there was no intention of permitting left-hand valves in a section of the system which was otherwise all right hand, it was not a matter of merely replacing the operating nuts with others correctly marked. Needless to say, it was a somewhat red-faced manufacturer's representative who corrected the situation to the department's satisfaction.

Line valves must be thoroughly checked again for ease of operation after completion of the pressure test. It is a common practice among contractors to exert unnecessary pressure in closing valves for a pressure test, and they have been known to bend stems in so doing; if this has occurred, it is best to discover the fact while the contractor's responsibility is still established. The follower, or packing gland, as it is sometimes called, must also be checked as these are almost invariably pulled down too tight by the contractor to prevent leakage during the test. The packing should be lubricated and the follower tightened just enough to prevent leakage; it will thus permit free and easy operation of the valve, and, should it later leak, it is easily accessible in the vault for additional tightening.

When a new main is to be connected to the existing system the use of a pressure connection with a standard tapping sleeve and valve is required, rather than permitting shutdown of the existing main. This is advantageous in that the control valve on the new main

is immediately adjacent to the existing main, making it possible to subject the entire new line to a pressure test and disinfection procedure. It avoids the nuisance of customer complaints, affords a stronger installation, and is considered by many contractors to be more economical. Several of the water main contractors in the Wilmette area have found it to their advantage to invest in the equipment required for pressure connections. A standard valve vault is built around these connections, but is made oval in shape in order to contain the entire tapping tee as well as the valve, thus keeping all joints easy of access for future maintenance.

Hydrant Installation

Fire hydrants in Wilmette are so installed that they will be located at intervals not exceeding 400 ft. The same manufacture of hydrants that was used in the earlier years of the water system continues to be used, for the same reasons as previously stated in discussing valves. For the past 15 years only steamer type hydrants with two $2\frac{1}{2}$-in. nozzles and one $4\frac{1}{2}$-in. pumper nozzle have been permitted to be installed. The hydrants are set on 6-in. branches from the water main, with 6-in. auxiliary valves, and the hydrant valve itself has a $5\frac{1}{4}$-inch opening.

Hydrants and auxiliary valves are checked before being lowered into the trench in the same manner and for the same reasons as given for valves. The hydrant is set in a vertical position upon a concrete block, which in turn must rest on solid, undisturbed soil. Wood blocking is used behind the hydrant bottom to the solid bank and between the sides of the hydrant bottom to solid trench walls. The importance of this blocking was well demonstrated on one occasion when a newly installed hydrant blew off the pipe and out of the trench.

Hydrants are not placed at street intersections—they are set back to the nearest property line to avoid damage by cars turning corners too sharply. The rolled curbs now so commonly used greatly aggravate this danger. Hydrants are set at a safe distance from both curb and sidewalk in order to eliminate the danger of injury to pedestrians and cyclists, and to minimize the possibility of breakage by sidewalk snowplows during snow storms, when visibility is poor.

Approximately $\frac{1}{3}$ yd of stone is used around the hydrant drain to assure good back drain. All joints and flanges on the hydrant and the auxiliary valve are left fully exposed until completion of the pressure test, and are thoroughly checked after this test. The same procedure is followed as that for line valves, except that, as the hydrant auxiliary valve is to be set in a box where it will not be easily accessible in future, the packing gland is tightened more than on line valves.

Communication and Repairs

Radio communication has proved a great advantage in the maintenance program. The foreman's car and a department pick-up truck are equipped with two-way FM police radios, and more installations are planned in the near future. Direct communication is thus possible between crews as well as between the department, police headquarters and all squad cars. It is of special value at night when public phones are not available, and makes possible close coordination of operations when two or more crews may be scattered over a wide area. As the fire department is on the same frequency the water and sewage department can

notify them promptly when a hydrant or a certain section of water main is taken out of service for repairs and when it is restored to service. Hearing other calls over the air also brings about an understanding of each others' problems and creates a feeling of friendship between the police and the water department; whenever the department finds it necessary to close down valves at a busy intersection or street at night, one or more squad cars invariably come to assist in controlling traffic.

Hydrants are operated only by the fire department, the water department, or street sweeper operators. The fire department and street sweeper operators check each hydrant after use for proper backdrain, and any hydrants found to drain improperly are promptly reported to the water department. On rare occasions, paving contractors are given permission to use certain designated hydrants, and these are thoroughly checked by the water department after such jobs are completed. Strict enforcement of these regulations may be the reason why Wilmette has never suffered from frozen hydrants, although no efforts have ever been made to check hydrants in the fall for water standing in the standpipe. In early years, each winter was faced with fear and worry, but the manpower with which to make the necessary survey annually was not available. Each passing year without trouble brought added reassurance; records indicate that, during the past 10 years, there has been only one broken hydrant which could possibly be attributed to frost damage, and it could as easily have been struck by a vehicle for there was a horizontal crack in the standpipe at ground level as well as the tell-tale vertical crack.

One of the major problems of hydrant maintenance in the older sections of Wilmette arises when it becomes necessary to replace a broken hydrant. Although the old hydrants were standardized, the flange drillings on the auxiliary valve, the hydrant bottom, and the standpipe were apparently made at random instead of following a pattern. Four, six, and eight-hole flanges are found, and it is consequently not possible to stock items for replacements in advance of need. The hydrant must be unearthed, one or more templates made, and a special replacement ordered. The particular section involved is thus left without fire protection until the replacement is received. The fire department must be notified of the necessity to use adjacent hydrants in case of fire, and water department personnel immediately check these adjacent hydrants for perfect operation.

Hydrant Inspection

In checking a fire hydrant the following procedure is observed:

1. With one nozzle cap removed, the hydrant is fully opened and the flow of water observed.

2. If satisfactory, the hydrant is closed, the nozzle cap is replaced, and all nozzle caps are tightened.

3. The hydrant is then again fully opened, the standpipe examined under pressure for cracks, nozzles checked for leakage in the lead joints, and the packing gland checked for leaks.

4. With the hydrant still open, the auxiliary valve is closed to check for complete shutoff and ease of operation.

5. While the auxiliary valve is closed one nozzle cap is removed and the auxiliary valve is then reopened.

6. The hydrant is shut off and backdrain is checked by holding one hand

over the nozzle—strong suction should result. If these tests prove satisfactory the hydrant is approved and no further work is done.

Should the hydrant fail any one of the tests, the following procedure is observed:

1. The auxiliary valve is shut off and the hydrant dismantled—a very easy task with the hydrants used in the community, and one which can, if necessary, be done by one man.

2. The hold down nut is removed and the operating nut lifted off (this may require light tapping underneath the nut with a small hammer.

3. The packing gland is loosened to relieve pressure against the valve stem (a special box wrench should be used for this as the packing gland can easily be compressed and damaged with a pipe wrench).

4. The cover can now be easily lifted off, the drain lever bolt and lever are removed, the hydrant stem is held out of the way, the drain support, or drip-cup, is lifted out, and the entire drain rod is removed and inspected.

5. If the rubber drain valve shows excessive wear or abrasion, the bronze retaining nut is removed and a new rubber is installed.

6. The hydrant operating nut is set loosely upon the stem and, with a hydrant key, the stem is turned two or three times in a clockwise or opening direction, after which it is easily screwed out by hand and lifted out together with all operating parts of the main hydrant valve, which can then be examined, and the valve rubber replaced if necessary. As on this type of hydrant the valve is free to turn upon the stem when the valve is being closed there is rarely any evidence of abrasion; the life of these valve rubbers is truly astounding.

This operation is reversed in reassembling the hydrant. The stem and valve are screwed into position and tightened. The drain rod is replaced, and pushed firmly into the drain—this is the most difficult part of the procedure and occasionally requires the use of a little patience and a few well chosen words. The drain in the hydrant bottom often decides upon a little game of hide and seek at this point. If the day is sunny, it is possible to see the drain opening by holding a small mirror at the proper angle to reflect the sunlight into the standpipe. Before proceeding with the reassembly of the other parts of the hydrant, the operating nut is set on the stem and the hydrant valve is opened sufficiently to fill the standpipe with water to the nozzles. The drain rod is then raised by hand and the rate of drainage is observed. If this is not rapid enough, the drain is completely removed, and the drain opening is reamed with a homemade tool—usually a brass curtain rod bent slightly to resemble the drain rod and sharpened at the end. The drain rod is then replaced, the balance of the hydrant is reassembled, and again given the full operating tests. In reassembling the hydrant, the packing gland is completely removed, and the old packing is replaced with new, well lubricated material. The department is now experimenting with the new molded-rubber packing which may prove far superior to the present braided asbestos, if it will withstand the heat absorbed from the sun by the packing gland without softening. The department is also experimenting with O-ring stuffing boxes on a few of the new hydrants; it is possible that braided asbestos may soon become as obsolete as lead joints in water mains.

Valve Repairs

The valve maintenance problems have not been too great in the past. As previously stated, when a valve proves completely inoperable, it is replaced with a new one cut in under pressure. It has been learned from experience that most of the difficulties in obtaining complete shutdowns usually attributed to faulty valves in system are not actually due to faulty valves, but rather to faulty operation. Complete shutdowns of areas in which old records indicated this could not be done, have been successful. The following procedure for valve operation has therefore been set:

1. Keep calm, as nothing can be gained and much damage can be done by a frenzied rush from valve to valve, twisting each as far as possible.

2. Mark the scene of trouble on a map of the distribution system, determining the smallest possible area to be shut down, and marking in red pencil the valves involved.

3. With the nearest fire hydrant open, turn each valve as far as possible without applying undue strain, counting the number of turns.

4. When the limit is reached, open the stem four or five times, and close again as far as possible.

5. If sand or sediment lie under the gates, this opening and closing action will, because of the partial closing of the gates, increase the velocity of the water and flush out the sand or debris, as well as whatever corrosive debris may have been on the gate or the seat.

6. If water continues to flow from the hydrant, repeat the process.

7. Open the hydrant nearest to the first valve, and monitor the valve key with an earphone; if the sound of water passing through the valve is heard, a man with a chisel and steel brush goes down into the vault to clean the operating nut and determine from the marking if the direction of turn is correct.

8. If it is correct, continue the operation of completely closing and partially opening the valve, carefully counting turns to determine how much is being gained, until sound of water is no longer heard.

9. If no marking exists on the operating nut, or if corrosion is too great to permit the arrow to be seen, operate the valve fully in the direction opposite to that previously tried; occasionally it may be found that a left-hand valve exists where a right-hand one was indicated, or that a supposedly open valve has been closed for years.

10. When the sound of water is no longer heard from a valve, tackle the next, and continue until all valves involved have been operated, and shutdown has either been achieved, or shown to be impossible. If impossible, the earphone has at least indicated which valve was not accomplishing its purpose. This valve is marked for immediate attention as soon as the emergency is under control. By means of the distribution system map, the extent of additional area required to be shut down is then determined, although this is rarely necessary.

When the immediate emergency has been taken care of and one or two valves have been opened to check the repairs, the process of restoring the system to full service is accomplished in the same manner as the shutdown; each valve opened is marked off on the same distribution system map that was used in the shutting down procedure; the valves are checked for stuffing box leaks and packed if necessary; valves which

were hard to operate are checked more thoroughly by removing the follower and replacing all packing, and once again checking for operability; valves requiring extensive repairs are then scheduled for the necessary work, preferably at night if many consumers will be affected.

Most Wilmette valves are of the double-disc, taper-seated type, and damaged stems often are replaced without depriving any consumers of water. If the gates can be closed (though not necessarily entirely), the operating nut, follower, and packing gland are removed, and the valve cover is carefully lifted, maintaining downward pressure upon the stem in so doing. Blocking is then installed against the valve ball to prevent the gates from slipping up and the stem is screwed out of the ball. The blocking is usually a piece of 2 × 4-in. timber wedged against the inside of the vault frame and against the edge of the ball. A new stem is as easily screwed in, and the valve reassembled. It has been found that it is possible to carry out this work in a vault if a good pump is used, even with a considerable amount of water flowing past the partially closed valve gates.

If it is necessary to shut down a section to repair a valve, the consumers involved are notified in advance and the work is done at night. If it is discovered that the valve is of unknown make or requires parts which are not on hand, a steel plate with a rubber gasket is bolted to the valve body flange, and the section is restored to service, thus affording time in which to work on the internal valve parts in the shop and to order replacements if necessary. The same procedure of notification, night shutdown, and the assembling of new parts in the valve is then followed.

Conclusion

The water department is constantly attempting to improve its distribution maintenance system. The village is fortunate in having filtered water in the mains and neutral ground water outside of the mains, so that bronze or cast-iron materials suffer little damage from corrosion. It is hoped that readers of this article may make suggestions concerning further improvements.

Rate Making for Small Water Works

Albert P. Learned

A paper presented on Oct. 15, 1956, at the Southwest Section Meeting, Little Rock, Ark., by Albert P. Learned, Prin. Engr., Black & Veatch, Kansas City, Mo.

THE water works operator in most cities and towns is conscious of the fact that the water supply and its conservation and proper use are rapidly becoming a nationwide problem. The recent drought stopped the flow in many rivers, and, in many areas, underground supplies of water are being and have been withdrawn more rapidly than they are being replenished.

The water supply problem has been further influenced by the growth of cities and the increase in industrial requirements. These various demands no doubt can be met, but doing so will require a fuller appreciation of the necessity of water conservation, and, in some localities, may require the clear definition of priority in the use of water.

These conditions do have a bearing upon water rates because the increase in water use has necessitated enlargement of facilities for production, transmission, and distribution, at a much higher cost level per unit of plant than existed prior to the end of World War II. This situation has in many places substantially increased the debt structure of the utility, with attendant fixed charges and annual requirements for depreciation.

A customer often reacts as though he felt that the only investment made to render him service was the pipe extension in front of his own home, plus the amount the utility may have invested in his meter and the distribution apparatus in his street. It is important in public relations, as well as in rate matters, that the customers and the department realize that the cost of main extension or distribution mains as a whole is normally less than 50 per cent of the investment required to render the service. Other portions of the plant essential to providing service are the production, storage, transmission, service, meter and hydrant, and general plant portions. Table 1 shows how this investment in the several parts varies with different sources of supply and in different localities. The last example is of a city in arid, mountainous country where source of supply and production plant comprise a larger part of the investment. In this city, the department owns few meters and services; in fact, it is, today, sorely pressed for supply, primarily because of a flat-rate schedule for residential customers, which results in waste from leaky plumbing fixtures and careless sprinkling and general use by the public.

Revenue

There is one essential in the making of rates regardless of the size of the community—namely, that the charges produce sufficient revenue to provide a satisfactory water service, and that such revenues be collected equitably from the various groups of consumers.

Revenue must provide funds sufficient to pay:

1. All necessary operating and maintenance expenses

2. All costs of minor extensions to the system, rather than a financing of such minor extensions

3. All fixed charges applicable to the plant account. These include:

a. In certain states (where there is state regulation of municipal utilities), annual charges for the depreciation reserve, plus return on the rate base (In such states, depreciation reserve and return furnish the funds to build minor extensions. Major extensions are financed by bonds, which, in turn, are amortized through depreciation reserve and return on the increased investment.)

b. In cities and towns where regulation is subject to a city council, the payment of interest on debt and the amortization of debt (If the normal annual charges for depreciation were equal to, or greater than, the amortization of debt, the charge would need to include only the interest on debt and the annual charge for depreciation, to make it sound.)

c. In cities and towns where regulation is subject to a city council, and where major improvements are being financed by the use of revenue bonds, the banker's requirement for a margin of 30–100 per cent (roughly, the actual debt requirements for the bond term), which often proves sufficient to build minor additions and provides additional amounts for a depreciation reserve which can be applied to a later major expansion or more rapid retirement of debt.

It has been pointed out that revenue must be sufficient; the next point is that of insuring its sufficiency. Revenue, of course, is a function of the number of gallons of water sold and the price at which it is sold. It has been common practice to have a low minimum charge and, for that minimum charge, to include enough water to satisfy the use of many customers for many months of the year. The result is a large number of minimum bills producing an inadequate amount of revenue. This situation is not peculiar to small towns, but applies to larger cities as well. A review of several bill analyses has produced the data shown in Table 2. In Milwaukee, it is found that approximately 50 per cent of the bills are for 7,000 gal per month, or less. The tabulation indicates the average customer usage to be less in the

TABLE 1

Allocation of Investment in Various Water Works *

Source of Supply	Production Plant	Transmission	Distribution Mains	Service, Meters, Hydrants	Storage Plant	General Plant
Well	17	—	35	34	8	6
River	30	7	37	17	—	9
Well and River	28	—	51	16	3	2
Well	15	—	45	27	9	4
River	36	—	50	10	4	—
Well	52	—	24	18	5	1
River	64	—	30	2	3	1

* All figures are percentages of total investment.

small-size town than in the larger city. This may not be as great a per capita difference as indicated, because water is ordinarily sold through a single meter, even though it may be to a building that includes several apartments. The multifamily situation is met at Fargo, North Dakota, by a service charge plus a commodity charge rate in which the service charge is dependent upon the number of single-family units served through a single meter.

Unique Problems in Water Supply

The water system furnishes, at a very low cost, a product that is most essential and for which there is no substitute. Nevertheless, the industry (particularly the municipally operated utility) has been, in most instances in the past, either unaware of or negligent in appreciating the value and full cost of the service. Only a very serious need of additional revenue has forced the problem to the forefront of the industry's attention. It finds itself confronted with the need for more revenue to meet additional operating cost per unit of production, and to meet the increased cost of financing plant expansion. The gas industry may seek out an interruptible customer, serve him well in the summer and partially in the winter season, and thereby level the load factor. The electric industry has air-conditioning use in the summer and the added lighting load in the winter, plus the benefit of many new appliances that tend to produce a good annual load factor and more income.

The water works industry, however, finds itself confronted with a business that has but one peak season of relatively short duration. When it is hot and dry, there is the sprinkling load, and, at the same time, there is the added load of air conditioning. In the winter season, however, when the department has capacity of plant to deliver and a sufficient water supply, it seldom can find a customer where requirements will tend to improve sales and revenues. The industry, then, is faced with a summer peak period, and is required to provide plant to meet that season's extreme loads.

It is true that the automatic washer and the disposal unit have added some load; however, its impact on an improved load factor and added revenues is relatively small.

Many municipally owned water utilities secure little or no revenue from the city's general fund to correspond to the hydrant rental charge made by the private utility, and this is a further loss of revenue. Unfortunately, today's

TABLE 2

Typical Customer Usage Relative to Size of Community

City	Number of Customers	Percentage of Total Bills	
		0–2,000 gal	2,001–5,000 gal
Erie, Kan.	480	40	40
Marshall, Mo.	2,560	37	—
Emporia, Kan.	5,000	34	29
Owensboro, Ky.	10,000	20	45
Milwaukee, Wis.	125,000	5	27

general taxing system is in bad shape to meet the requirements of nonrevenue-producing services of a municipality.

Fire Protection Costs

The water system is built primarily for two purposes: to safeguard the community against losses due to fire and to furnish a supply of safe and potable water. It is recognized that the customer should pay for the water he uses; however, too often the community's responsibility to defray the costs of fire protection is ignored. The value of fire protection to the individual and community correspond more nearly to the normal tax base—that is, the more property protected for an individual, the fairer it is that he pay on the basis of the value of that property, rather than upon the basis of water consumed. There are instances, of course, where an owner who has extensive properties and whose water consumption is nil benefits insurance-wise from the fire protection afforded by the water system.

The industry has failed generally in municipal systems, and to some degree in private systems, to secure the proper recognition and acceptance of the community's responsibility to defray the fire protection costs. Special fire protection systems, such as sprinkler systems within a building, whose entire effectiveness is dependent upon its connection to the water system, have been recognized, generally, to warrant a monthly charge for such connection to the main. This charge is generally proportional to the size of the connection.

The necessity of securing adequate revenue from water consumers and an adequate community charge for fire protection is something all towns and city water departments should strive to secure.

In the AWWA water rates manual (*1*) the application of a suggested basis for fire protection charges showed an annual charge of approximately $1 per capita for the larger cities, and more nearly $2 per capita for cities of 10,000 population and less.

The situation requires a substantial minimum charge to customers, to insure adequate revenue. This substantial minimum is warranted, as was indicated in the number of bills that are for relatively small amounts of water, and when it is realized that plant investment averages $300–$400 per customer in many properties. These minimum bills for 2,000 gal per month and less in many smaller cities will require a minimum of $2–$3 per month.

It has, unfortunately, been too long the practice in the water works industry to have a low minimum charge, and a charge too low for water in the last bracket of the rate structure. The lack of an adequate minimum charge has produced too little revenue because of the large number of customers paying such charges, and inadequate remuneration from the large consumer has further jeopardized the revenue.

Cost-of-Service Data

The small water plant, defined as one with 1,000 water customers or less, does not have a large staff. In fact, in the smaller units a typical staff would consist of the men at the plant who treat the water and see that it is delivered into the system and, perhaps, one man who does all of the operating and maintenance of the distribution system; in the office, perhaps a man who reads the meters, takes calls, and, with the aid of a woman clerk, computes all water customer bills, collects payments, and does whatever accounting is necessary. Under these conditions, the operator wonders how he can maintain

records that are of any value in analyzing rates. This is simpler than appears at first glance. For instance, the statistics which are valuable in a rate analysis and which should be recorded are:

1. Total water pumped, in thousands of gallons or hundreds of cubic feet
2. Total water pumped into the distribution system
3. Total water sold and revenue derived
4. Estimate of water not sold, but accounted for
5. Number of customers—divided into single-family, multifamily, and commercial customers.
6. Data on department's debt and interest requirements
7. Data on depreciation accruals, both annual and total.

Expense data from the production plant should include the cost of labor, chemicals, energy for pumping, and supplies. This may be conveniently subdivided into source of supply, pumping, and treatment expense. Data on expenses of the distribution system should cover the cost of labor, divided according to operation, maintenance, and supplies. Maintenance can, perhaps, be further subdivided into distribution mains, services, and meters. In the general office, the costs of labor and supplies, divided into customer expense and general accounting or statistics should be included.

These data, together with a detailed bill analysis and a relatively accurate plant account can provide a basis for the development of a reasonable rate schedule.

Most meter readers have recorded on each account card the size of the meter installed, which affords data on the customer's potential demand on the system.

In small towns there are relatively few nonconserved, water-cooled air-conditioning units, and their location is quite common knowledge. A review of those customers' bills throughout the year will quickly determine their requirements in the hot months, and safeguards may be provided in the general rate structure, or by the introduction of a special rate.

TABLE 3

Price Trends in Representative Water Works Installation *

	1914	1926	1930	1946	1956
Water pipe (6-in.) laid, per foot	$ 0.66	$ 1.35	$ 1.05	$ 1.89	$ 4.00
Valve (6-in.) and box, placed	15.00	44.52	29.37	59.24	95.00
Hydrant valve (4-in.) with two 2.5-in. nozzles, placed	28.80	67.75	55.39	127.00	160.00

* Prices are for work in the same region and conform closely to trends shown in the AWWA Water Rates Manual.

The data can be analyzed, and demand, commodity, and customer cost developed together with special services. General subdivisions of expenses will be production, distribution, hydrants, services, meters, and customer or commercial expenses. The general subdivisions of plant will be production, distribution, customer facilities, hydrants and connections, and general plant.

Meter sizes are often used as a basis for computing potential demand, with proper diversity factors for dif-

ferent customer groups, such as residential and commercial. Required fire flows measure the potential fire demand, and water delivered furnishes the unit upon which commodity cost is allocated. Customer costs normally are dependent on number of customers served, and are so allocated.

The only refinement the larger system may employ is that of dividing expenses and investment into more specific parts, having more studies of special loads, and more accounting and statistical data, which reflect climatic and special conditions in a more detailed manner.

There are still some municipal water utilities burdened with rates established years ago which are not in line with present costs. Table 3 shows the trend in prices and indicates the increased costs of plant as well as maintenance in recent years. The prices are for work in the same general region.

If a water utility's charges in earlier years were equitable, it is certainly necessary that they be raised under present conditions in order to absorb increased costs of labor and materials and provide for fixed charges on plant.

Special Rate Problems

The General Waterworks Corporation of Arkansas was the first to secure a decision from its state regulatory commission authorizing an extra charge for water used in nonconserved air-conditioning units. This was certainly a forward step, and furnished many water utilities the incentive to secure proper compensation for a wasteful seasonal addition to the system peak requirements. The annual surcharge per ton for nonconserved units was set at $12.50. In subsequent cases under different conditions, the annual surcharge authorized has reached $40.00 per ton for nonconserved air-conditioning units (St. Louis County, Mo.). The amount of such a load and its effect on system operations varies with the locality and with different years in the same locality. But it is always a potential threat to satisfactory water service because of its quantity requirements.

Lawn sprinkling poses certain problems in peak considerations; these, however, are usually solved without serious impairments in service. Sprinkling problems are usually most severe in communities where flat rates are still in effect. Fortunately, these are being gradually superseded and meters are being installed.

The operator and the governing board of a water utility must recognize that it is impossible to render satisfactory service without adequate funds; that the service rendered is of real value; that equitable rates impose no undue burden; that a fair rate structure will not drive industry out of a city; and that the utility must have adequate revenues if it is to furnish proper service and be prepared to meet the requirements of future growth.

Rates in the small towns must meet these requirements too, with the only difference from the larger cities being the ratio of the primary subdivisions of cost of service—namely, demand, commodity, and customer costs. Local conditions influence such costs, and it can rather safely be said that comparison of water rates is of less meaning than comparison of rates of electric and gas utilities. It is imperative that each water utility determine what rate structure will fit its requirements, irrespective of what other water utilities charge.

Reference

1. *Water Rates Manual—AWWA M1.* Am. Wtr. Wks. Assn., New York (1957).

Water Quality Problems in Small Water Works Systems

Carl B. Johnston

A paper presented on Apr. 26, 1957, at the California Section Meeting, Santa Monica, Calif., by Carl B. Johnston, Engr., Pomeroy and Associates, Pasadena, Calif.

THE "safety" or sanitary quality of a water supply may be likened to the trustworthiness or character of an individual. Trustworthiness in a person cannot be measured by a simple test such as weighing the subject, but is established by a long history of satisfactory performance and is often evaluated by extent and frequency of deviations from the normal. So it is in determining whether water supplies are trustworthy—whether "safe water" is actually being distributed. Safety in water quality is relative, not absolute, and sampling and analysis techniques simply establish a history which, in one's best judgment, indicates that the danger in consuming the water is so small that it may properly be disregarded.

Standards of Quality

Certain standards of water quality, divided into three main categories, guide the judgment of results:

Physical. Such attributes as color, turbidity, taste, odor, and presence of visible organisms are readily apparent. They are tolerated by the consumer in varying degrees, dependent upon availability of alternate supplies and the cost of treatment. Although numerical limits for color and turbidity are established in the USPHS Drinking Water Standards (*1*), many supplies exceed these values without causing concern. Generally the customer is the best judge of physical quality.

Bacteriological. The water works operator strives to produce water completely free from coliform organisms. Sanitary acceptability is commonly evaluated by two criteria, the first of which is the MPN (most probable number) of coliform organisms found in a given quantity of the water. Not harmful in themselves, coliform organisms include *Esch. coli* and *Aer. aerogenes.* Both are found abundantly in sewage and both also grow on cellulosic material outside of animal bodies. Coliform organisms tend to predominate in fecal matter, whereas growths on vegetable matter are often mostly *Aerogenes.* The commonly applied USPHS Drinking Water Standard (*1*) involves taking at least one sample per month and dividing it into five 10-ml portions. Not more than 10 per cent of the 10-ml portions examined per month may show the presence of organisms of the coliform group.

The second criterion is the sanitary survey, which indicates possible sources of contamination causing unusual densities of coliform organisms.

Mineral. Usual standards for mineral quality are those of the USPHS for drinking water supplied by common carriers in interstate commerce (*1*).

These mineral standards are a curious collection of objective values, safe limits, and administrative limits. Sometimes these standards have been misunderstood and have been looked upon as maximum allowable values beyond which toxic or other adverse effects might be expected. Although in some instances the individual numerical limits appear to be related to levels at which adverse physiological effects might begin to be observed, it cannot be assumed that one or more constituents in excess of the standard would make the water unsatisfactory for ordinary use.

The chemical or mineral limits specified by the USPHS are shown in the appendix.

With the realization that water quality standards are somewhat flexible, and that there is no fixed point at which a water suddenly becomes unusable, some of the common water quality problems which confront the operator as he endeavors to produce a water which is safe and acceptable for his consumers can be considered.

Bacterial Counts

In surface sources, departure from normal bacterial count may occur as a seasonal change, related to the flow in the stream. In one instance, a change in the sanitary quality of the water was correlated with the opening of fishing season. There are varying opinions about proper uses and protection of watersheds and about recreational use of water supply reservoirs. Experience supports the view that properly controlled recreational use is satisfactory for large supply reservoirs. An impounding reservoir of a small water works must generally be closed to recreational use, and habitation of the watershed must generally be minimized.

Surface supplies in inhabited areas should be chlorinated, and, usually, dual chlorination equipment will be required so that failure of one chlorinator will not allow unchlorinated water to enter the distribution system. If it is not possible to protect the source against substantial contamination or the threat of such contamination, then the water must be filtered as well as chlorinated.

High bacterial counts in a well supply will usually indicate improper sealing at the surface of the well casing. Complete sealing of a domestic well from the effects of surface drainage is, of course, mandatory. If the well is adequately protected against surface contamination but shows bacterial counts, the well may be given a heavy chlorine treatment. Hypochlorite solution should be added and mixed to give a high concentration—about 50 ppm in the casing. This solution should be left in the casing for several hours, then pumped out. Very effective disinfection can also be accomplished with a heavy dosage of caustic soda or lye. A concentration of 2,000 ppm is recommended.

Such treatment may have only temporary effect, especially if there is a continuing source of contamination nearby. For example, one water company well which had shown no bacterial counts in many years of service, suddenly produced counts with the nearest known source of possible contamination a cesspool 81 ft away.

With such conditions as these it will usually be advisable to chlorinate the water from the well, thus providing an effective and easily controlled defense against bacterial contamination.

Positive *Esch. coli* and *Aer. aerogenes* counts in reservoirs supplied only with water free of contamination may

be due to the droppings of warm-blooded animals or birds. In covered tanks, the condition is usually corrected by properly screening all points of entry. Another possible source of high counts of the coliform group is growth of these bacteria in the reservoir, on wood or other cellulosic material. Difficulty in one reservoir apparently resulted from the presence of wood columns and in another it was caused by wood baffles. Since it is almost impossible to accomplish effective disinfection of wood surfaces, it is best to remove the structures if they are causing trouble.

Aer. aerogenes and *Esch. coli* growths in a distribution system may occur if cellulosic material is present. The use of jute packing in making joints in cast-iron pipe has sometimes encouraged such growths, and jute packing is now looked upon with disfavor.

Troublesome bacterial counts often arise following construction and repair of distribution systems. It goes without saying that all foreign matter should be excluded from pipelines under construction. Standard procedures now call for disinfection of mains before placing them in service, usually by applying a chlorine dosage of 20–50 ppm to the pipe contents for a 24-hr standing period.

One of the sources of contamination most difficult to detect is that resulting from cross connections. Even with a diligent program of elimination, some unsuspected cross connections are likely to remain in most water supply systems. The most common source of possible contamination is the garden hose, which may be left in such a position that dirty water may be drawn into the water system under negative pressure. One could not expect that this would often be a cause of disease, but it is, at least, a hazard.

Sometimes hoses connected to a public water system are used for operation of chemical sprayers. In 1956, two men in a Southern California city became quite ill for a short time after drinking water from a convenient garden hose. Investigation failed to establish the cause with certainty, but apparently there was some toxic substance in the hose. Fortunately the public water supply was not affected, but the possibilities are apparent.

The water purveyor should do what he can by education and enforcement, to eliminate cross connections, and then he should operate his system on the assumption that cross connections exist. This means, first and foremost, that a positive pressure must be maintained in the mains at all times.

Chemical Content

Dissolved forms of many of the so-called heavy metals are known to exert an adverse effect upon persons continually consuming such water. Salts of lead, copper, zinc, mercury, cadmium, selenium, and chromium have been discussed in water supply literature, and rather strict limits have been placed on most of these elements by water supply and health authorities. Present limits of 0.05 ppm for selenium and hexavalent chromium in the USPHS Drinking Water Standards (*1*) appear quite unrealistic from the standpoint of actual toxicity. There is little actual information about toxic concentrations of chromium, and what there is does not suggest that there is cause for concern until the concentration of hexavalent chromium exceeds at least 1 ppm. The smallest concentration at which symptoms have been noted is 5 ppm. But it is unquestionably true

that the mere finding of chromium suggests the presence of a source which could become hazardous. Almost invariably, the presence of more than trace amounts of heavy metals in a water supply indicates industrial waste. Although these metals may be removed from the water by treatment, a more positive approach is location and correction of the source of industrial waste.

Nitrate in drinking water at levels in excess of about 50 ppm (as NO_3) is considered undesirable where the water may be consumed by infants. Blood changes and consequent cyanosis may be caused by high nitrates in feeding water. Nitrates are the end product of the aerobic stabilization of organic nitrogen, and as such they occur in polluted waters that have undergone self-purification or aerobic treatment processes. Nitrates also occur in ground waters as a result of extensive applications of fertilizer or leachings from livestock yards or cesspools. No community in California is known to be attempting reduction of nitrate in its supply except by dilution of high nitrate sources with other sources of low nitrate content.

Fluoride content of drinking waters has received much attention recently with respect to its effect upon the rate of tooth decay in growing children. Many water supplies in California contain fractional parts per million of fluoride, and occasional supplies show 10 ppm or more. About 1.0–1.5 ppm is considered optimum in the control of dental caries, and two or three times this dosage may begin to cause conspicuous mottling of tooth enamel. It is interesting to note that as, of Oct. 1, 1956, the USPHS tabulation showed that 30,470,272 persons in 1,426 communities served by 705 water systems were using artificially fluoridated water. The operator of every water system should be prepared to tell his customers the natural fluoride content of the water delivered, and, if fluorides are being added, he should, of course, maintain an adequate program of control and testing.

Such substances as arsenic, antimony, barium, cyanide, and numerous others are toxic in water solutions at extremely low levels, but fortunately these substances seldom occur naturally. As a result of combination, precipitation, or decomposition, these elements usually do not persist in a water supply. When found, these "unnatural" elements usually indicate the presence of man-made materials such as industrial wastes, insecticides, and commercial poisons which may best be controlled at the source.

While the preceding discussion has concerned itself with elements affecting the health of the consumer, numerous problems result from need for maintaining high aesthetic standards in water supplies for human consumption. Among these aesthetic considerations are appearance, taste, and odor.

Appearance

Colored water is one of the most frequent complaints in the small water system—usually as "red water." Red water is caused by the presence of iron, manganese, or both in the supply; by a corrosive water supply; or by both of these factors.

Iron "bacteria" often flourish in distribution systems which have iron or manganese dissolved in the water, but they are a symptom and not a cause of the presence of these substances.

When well water containing iron or manganese in solution is delivered to storage tanks and comes into contact

with air, oxides of iron or manganese will form and settle out in the distribution system, usually in areas of poor circulation. Iron compounds precipitate readily, whereas manganese requires more time for reaction. The iron organisms hasten the precipitation of iron and are practically essential for precipitation of manganese.

In a coastal community near San Luis Obispo, Calif., manganese floc precipitated in the street mains several days after leaving the well. Because of lack of oxygen, the water retained manganese in solution until sufficient contact with air occurred in the final storage vessel.

When analysis shows more than about 0.5 ppm of iron or manganese in the raw water, a satisfactory method of removal is aeration followed by settling and filtration, in either an open or pressure system. Where the water can be isolated from air prior to treatment, these troublesome elements may be removed in a special filter, which is regenerated at intervals with potassium permanganate. Under some conditions, iron and manganese less than 0.5 ppm may be "sequestered" or prevented from acting, by feeding a few parts per million of complex phosphates before exposure of the water to air.

In addition to iron present in the supply, iron may be introduced into the system by the corrosive action of water on iron pipe, particularly in areas of poor circulation. Here it is important to correct the corrosive nature of the water, insofar as possible, by reducing dissolved oxygen or raising the pH to bring the water to saturation with calcium carbonate. Flushing of dead ends is likely to be necessary to reduce complaints.

Turbidity in a water system most frequently arises from presence of clay, silt, finely divided organic matter, and aquatic organisms in the source. Occasionally, however, secondary reactions will take place in storage tanks and distribution systems, resulting in precipitation of metallic hydroxides which make the water cloudy. In treated supplies, insufficient time may have been allowed for completion of chemical reactions at the point of treatment, and a chemical precipitate, or "after-floc" may form in the distribution system. Prolonged storage before delivery into the distribution system usually provides sufficient time for settling visible particles which cause objectionable turbidity. In extreme cases of inert turbidity, aesthetic considerations may require filtration through sand or diatomaceous earth.

Although apparently not a significant problem in California water supplies, snails, worms, and larvae in distribution systems have been reported (*3, 4*). Eradication of these pests seems to be accomplished generally by removal of their food supply coupled with chemical treatment or physical cleaning, followed by flushing of the mains before the dislodged organisms enter the meters and house plumbing.

Tastes and Odors

By far the greatest number of consumer complaints result from tastes and odors evident at the consumer's taps. Generally, these complaints fall into one of three categories: products of biological processes such as those of algae, actinomycetes, and other organisms; sulfides, usually caused by sulfate-reducing bacteria in the presence of organic matter; and chemical or medicinal tastes, often a result of some nearby industrial waste effect and sometimes a result of marginal chlorination. Moderate chlorination of

supplies tainted with these taste and odor-producing agents often accentuates them to the point where the water becomes unusable. Research by Silvey and Roach (*5*) indicates that aquatic actinomycetes (filamentous mold-like organisms) are responsible for a large proportion of the tastes and odors that occur sporadically in surface supplies, and which were formerly attributed to "disintegrating organic matter."

Unfortunately no universal cure can be prescribed for taste and odor problems, because any of numerous agents may be responsible. Individual investigation of each problem usually results in recommendation of one of the following relatively standardized means of correction: interruption of the life cycle of the bacteriological or biological agent, as by chlorination or other chemical treatment; introduction of oxygen into anaerobic waters, both to oxidize any sulfides present and to satisfy oxygen requirements of the sulfate-splitting bacteria; physical removal of causative agents by filtration or microstraining; chemical oxidation of odorous compounds, by free residual chlorination or chlorine dioxide treatment; and, for man-made causes, investigation and elimination of the source.

Special Needs

Another group of water quality problems which neither affect the health of the consumer nor offend his senses is concerned with special needs of certain consumers. Laundries, ice plants, steam plants, as well as the critical housewife, are sensitive to the hardness of water and are often concerned with the costs of treatment to make the water suitable for their needs. Decentralization of industry has emphasized the special needs of certain industries for water of low dissolved-solids content to prevent deposition of salts on rinsed metal parts. Food and beverage industries are particularly desirous of receiving uniform high-quality water which meets rigid specifications. Small water systems supplying substantial amounts for irrigation will find that their customers are interested in the content of boron, chloride, bicarbonate, and the ratio of sodium to the total of sodium, calcium, and magnesium. These factors determine the usefulness of water for irrigating certain crops, and, thus, may have a direct effect on the user's crop return.

Evaluation of Quality

Of the four types of tests required for full evaluation of a water supply—physical, bacterial, mineral, and the "transitory" field tests—the operator is usually prepared to conduct only the first and the last. He can judge color, taste, odor, and turbidity at all points in the system, and should do so regularly. For control purposes, or for other special interests, the operator may determine residual chlorine, pH, dissolved oxygen, or total sulfides. For accurate results the latter two tests must be made immediately after sampling, because their values change in transit—hence the use of the word "transitory." Bacterial tests are customarily made by the local health department, but if occasional checks are needed, the operator is usually aware that samples must be taken in sterile bottles under sterile conditions, and that samples must be refrigerated if not delivered to the laboratory immediately. Interpretation of results is normally furnished by the health department or analyzing laboratory.

Chemical or mineral analysis is usually done by a public or private laboratory upon submission of at least a 0.5-

gal sample in a clean, sealed container as soon as possible after sampling. The typical analysis consists of a series of specific tests for constituents commonly encountered in water supplies. Determination of small and trace amounts of every element present is neither practical nor economical.

The ordinary mineral analysis will reveal the following:

pH	Bicarbonate
Conductivity	Sulfate
Carbon dioxide	Chloride
Total hardness	Fluoride
Calcium	Nitrate
Magnesium	Iron
Sodium	Silica
Potassium	Boron
Percentage sodium	

Many other tests are available for specific elements; if tests are being made to answer some particular complaint, the operator should make this fact known to the laboratory in order that the proper analyses may be chosen.

Conclusion

Experience has shown that many aspects of water quality are interrelated. For example, corrosion, *Crenothrix*, and red water are related to the presence of iron, oxygen, and bacteria in a complex manner which is revealed after study of the particular problem. The answer to a problem in one system is not always the same in another, even though the symptoms may be similar. Just as the doctor inquires into the past medical history of his patient, so should the waterworks operator keep continuing records of water quality. Such records afford valuable background information when troubles arise, and they provide the alert operator with forewarning of probable complaints. Well-kept water quality records serve as good insurance against unreasonable claims upon the purveyor.

References

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3. Crabill, M. P. Biologic Infestation at Indianapolis. *Jour. AWWA,* **48**:269 (Mar. 1956).
4. Silvey, J. K. G. Bloodworms in Distribution Systems. *Jour. AWWA,* **48**:275 (Mar. 1956).
5. Silvey, J. K. & Roach, A. W. Actinomycetes May Cause Tastes and Odors in Water Supplies. *Public Works,* **87**:5:103 (May 1956).

APPENDIX

Portions of USPHS Drinking Water Standards—1946

4.1. *Physical characteristics* *—The turbidity of the water shall not exceed 10 ppm (silica scale), nor shall the color exceed 20 (standard cobalt scale). The water shall have no objectionable taste or odor.

4.2. *Chemical characteristics*—The water shall not contain an excessive amount of soluble mineral substance, nor excessive amounts of any chemicals employed in treatment. Under ordinary circumstances, the analytical evidence that the

* The requirements in section 4.1 relating to turbidity and color shall be met by all filtered supplies. Turbidity and color limits for unfiltered waters and the requirements of freedom from taste or odor for filtered or unfiltered waters should be based on reasonable judgment, giving due consideration to all local factors.

water satisfies the physical and chemical standards given in sections 4.1 and 4.21 and simple evidence that it is acceptable for taste and odor will be sufficient for certification with respect to physical and chemical characteristics.

4.21. The presence of lead (Pb) in excess of 0.1 ppm, of fluoride in excess of 1.5 ppm, of arsenic in excess of 0.05 ppm, of selenium in excess of 0.05 ppm, of hexavalent chromium in excess of 0.05 ppm, shall constitute grounds for rejection of the supply. . . .

Salts of barium, hexavalent chromium, heavy metal glucosides, or other substances with deleterious physiological effects shall not be added to the system for water treatment purposes.

4.22. The following chemical substances which may be present in natural or treated waters should preferably not occur in excess of the following concentrations where other more suitable supplies are available in the judgment of the certifying authority. Recommended methods of analysis are given in section 4.3.

Copper (Cu) should not exceed 3.0 ppm.

Iron (Fe) and manganese (Mn) together should not exceed 0.3 ppm.

Magnesium (Mg) should not exceed 125 ppm.

Zinc (Zn) should not exceed 15 ppm.

Chloride (Cl) should not exceed 250 ppm.

Sulfate (SO_4) should not exceed 250 ppm.

Phenolic compounds should not exceed 0.001 ppm in terms of phenol.

Total solids should not exceed 500 ppm for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 ppm may be permitted.

NOTE: Chemically treated waters have special pH and alkalinity requirements not listed here.

Recommended Meter Testing Procedure Available

The AWWA Meter Committee report on meter testing, first published in the June 1956 issue of *Willing Water*, was approved by the Board of Directors on Jan. 28, 1957, as a Tentative Recommended Procedure and has been given the designation AWWA C705–57T. Reprints, in the usual 6 × 9-in. format, can be obtained for 20 cents each from: Order Department, American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Organizing a Safety Program

Mark B. Whitaker

A paper presented on Sep. 18, 1956, at the Kentucky-Tennessee Section Meeting, Chattanooga, Tenn., by Mark B. Whitaker, Gen. Mgr., Knoxville Utilities Board, Knoxville, Tenn.

PROTECTION of employees from accidental injury and damage to health is a responsibility of management. Modern management accepts this responsibility, and if any justification is needed, the following reasons for it may be cited:

Legal obligation. All states have laws that require employers to compensate for injuries suffered by their employees while on the job. Also required are reasonable safety standards for employee protection.

Social responsibilities. A safe working condition is a moral obligation imposed by society. The increasing emphasis on accident prevention has been evident for many years. Management which fails to accept this responsibility will find that public opinion will support additional governmental regulations.

Economic necessity. Accident prevention is simply good business. The prevention of an accident costs less than its expenses—a fact that has been proved many times in the experience of thousands of industrial operations.

Safe working conditions and accident prevention can be accomplished only by the organization and the coordination of efforts of all concerned. The functions of a program to accomplish this objective are usually planned by the staff and administered by the line organization.

Frequency Rates

Organized safety programs in water utilities are comparatively new. Other utilities such as those in communications, power, gas, and transportation have had them for longer periods. The lag in water utility programs is partly a result of the fact that water works are generally small and have been operated as part of the municipal government rather than as an industry.

In 1945, the accident frequency rate in water utilities was approximately 35.46. This means there were 35.46 disabling injuries for each 1,000,000 man-hours worked. The latest figure available (1954) indicates that this frequency has dropped to 17.18, or about one-half of the 1945 rate. With such results, there seems to be no reason why water operations cannot establish a frequency rate comparable to industry or to other utilities. In 1954 the general industrial frequency rate was 7.22; the gas utilities rate, 10.51; the electric utilities rate, 8.62; and the communications frequency rate was 1.30.

Planning a Program

Planning and organizing a safety program presents a number of problems. The Knoxville Utilities Board, Knoxville, Tenn., has recently undertaken to plan an overall program which brings out many of the problems in-

volved. The board is made up of three operating units: the Bureau of Power, Bureau of Water, and the Bureau of Gas. The fourth bureau, the Bureau of Accounts, administers the accounting for the three operating bureaus. Each of the operational units has its own individual needs and procedures and these may differ from those of other bureaus. A safety engineer, reporting to the general manager, was selected to head the safety program for the entire board. He acts in an advisory capacity and handles all safety problems and procedures directly with the bureau superintendents, as they are charged with the authority and responsibility of their bureau operations, and he in turn keeps the general manager advised of the actions, procedures, and practices of each bureau.

The safety engineer has a secretary and a safety supervisor in the power bureau; another safety adviser has a joint responsibility of the water and gas bureaus as their maintenance and operation problems are somewhat similar. The safety supervisors are responsible for promoting safety in the divisions assigned to them.

Initial Implementation

The first step was to revise the rule books, so that, rather than being safety rules, they were prepared as a book of instructions and were issued as orders under the signature of each bureau superintendent. When a safety procedure is violated, therefore, the employee is not breaking a rule but disregarding orders. This gives the foreman and safety supervisors the backing they need in enforcing safety practices.

Each employee is given one of the instruction books and signs an agreement to abide by the safety instructions as long as he continues to be an employee of the board. He is required to know the instructions pertaining to his particular bureau, and from time to time questions or quizzes are given in order to be sure that the employees and supervisors are familiar with safety requirements.

Reporting and Investigating

The next step was to centralize accident reports and records. Accident reports concerning employee injury, public liability, and motor vehicles, are made out in the department in which the employee works, and a penciled copy of the report is forwarded to the safety engineer who makes additional copies. Copies are sent to the insurance carrier, the bureau superintendent, the division head, the safety supervisor, and the personnel director, and a copy is retained by the safety engineer for his files so that everyone in the organization concerned with the responsibility for the accident, or actions necessary to be taken resulting from the accident, has factual information for action.

The next step, which is essential in any safety program, is the investigation of accidents. Each accident of any consequence is investigated by a committee composed of three employees in the department concerned, the department head, and the safety supervisor. The safety supervisor acts as secretary and records the minutes. This committee is a fact-finding committee only and reports the results of its findings to the department head, who takes all disciplinary action. The aim of the committee's action is to keep all parties concerned informed and to insure absolute fairness of any disciplinary action that may be required. The foreman is the key figure in any safety program. Foremen meetings have been organized in which not only safety, but other mat-

ters are discussed. These meetings are held at least monthly and from time to time in the meetings, a representative from the insurance carrier may be present, the board's attorney may discuss the Workmen's Compensation Act, or someone else may be there to discuss matters of safety. These meetings are held principally to emphasize the foreman's part in management and his responsibility in conducting a safety program.

Each month a report of all accidents is made, indicating progress or lack of it for the previous month and year. Every supervisor and foreman in the board receives a copy of these reports, and copies are sent to the insurance carrier's safety engineer in order to keep him posted on progress and to take advantage of any suggestions that he may have to offer.

Other Incentives

Each month the house organ, the *KUB Reporter,* has a column headed "Keep Your Name Out of This Column," in which all accidents, the name of the employee involved, his department, and a short description of the event, are given. A monthly safety letter is issued to all drivers—each letter conveying some suggestions on safe driving. The use of brakes, parking on hills, speeding, and maintenance of vehicles are the types of subjects covered. A safety suggestion box is kept in each department, and the employees are encouraged to offer any suggestions that will promote safety on the job.

Other means to stimulate safety thinking have been used—means such as outdoor safety banners, bulletin board safety posters, safety literature issued to supervisors, and safety articles in the house organ.

Conclusions

A safety program will be effective only if the cooperation of all supervisors and foremen is offered. If cooperation is lacking, only lip service will be paid, and no effective results will be shown in the reduction of accidents. Administering a safety program is not particularly complex compared to securing the cooperation of the employees who may realize the importance of their own safety, but are indifferent to the aims of management. Management must lead. If it is indifferent, employees will follow the example. Anything other than a planned persistent effort will be fruitless.

1956 Safety Record at Chicago

The Chicago Department of Water and Sewers 1956 report on the operation of the safety program in the Bureau of Water provides some interesting statistics. Table 1 lists statistics relating to the nondisabling and disabling accidents for the year, by division and work classification. The table shows that slow progress is being made in reducing injuries. Two factors, no doubt, have a direct influence on the rate of progress: [1] the newness of the program which has forbidden a thorough indoctrination of all employees; and [2] the currently low accident frequency rate of water utilities which has made it difficult to show a sharp rate reduction in any year. It will be noted that injuries in the Collection and Distribution divisions are high. Construction and maintenance in these divisions are chiefly responsible for the higher rates.

TABLE 1

Injuries at Chicago Bureau of Water, 1956

Division	Avg No. of Employees	Time Worked *man-hr*	Nondisabling Injuries	Disabling Injuries	Time Lost *days*	Frequency Rate	Severity Rate
	Summary by Division of Bureau						
Administration	35	60,102	0	0	0	0.00	0
Collection	303	560,981	10	7	38	12.48	68
Distribution	1,613	3,270,285	168	38	1,653	11.62	505
Meter	98	199,217	12	0	0	0.00	0
Pump station operation	521	1,128,229	47	1	3	0.89	3
Purification	217	433,433	4	4	177	9.23	408
Total, 1956	2,787	5,652,247	241	50	1,871	8.85	331
Total, 1955	2,796	5,701,336	266	51	1,699	8.95	298
Total, 1954	2,645	5,345,998	271	51	2,029	9.91	380
Type of Work	Summary by Work Classification						
Engineering plan. & layout	95	193,215	0	0	0	0.00	000
Waterline construction	578	1,178,224	94	17	938	14.43	796
Waterline maintenance	738	1,504,248	64	15	412	9.97	274
Pumping cribs & tunnels operation	23	53,476	0	0	0	0.00	000
Pumping plant operation	484	1,050,281	47	1	3	.95	3
Water purification	115	238,679	3	2	46	8.38	193
Water safety control	31	60,853	0	1	129	16.43	2,120
Laboratory	26	47,855	1	1	2	20.90	42
Meter reading	148	292,336	6	5	29	17.10	99
Meter shop setting & inspection	143	290,121	17	2	6	6.89	21
Administration & clerical	365	661,276	8	2	9	3.02	14
Janitor	8	14,163	0	0	0	0.00	000
Watchman	33	67,520	1	4	297	59.24	4,398
Total	2,787	5,652,247	241	50	1,871	8.85	331

American Water Works Association

Standard Specifications

for

COAL-TAR ENAMEL PROTECTIVE COATINGS FOR STEEL WATER PIPE

The American Water Works Association has adopted and promulgates these "Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe." They are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions, and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

First Edition approved Apr. 25, 1940; revised 1949, 1950, 1951, 1955.
Second Edition approved Mar. 27, 1957

- **Price of reprint—45¢ per copy**
- **Approximate date available—Aug. 15, 1957**

AMERICAN WATER WORKS ASSOCIATION
Incorporated
2 Park Avenue, New York 16, N.Y.

Latest Revisions to C203 (Formerly C203 & C204)

On Mar. 27, 1957, the AWWA Board of Directors approved the publication of a new edition (the second) of Specifications C203, combining into one document the former Specifications C203 (applicable to pipe of 30 in. and over) and C204 (applicable to pipe up to 30 in.). The resulting revisions affect every section of the specifications, to a greater or lesser extent. All printings of the First Edition are obsolete.

Designation. The former designation, "C203–55," has been changed to "C203–57." The C204 designation has been eliminated.

This printing contains all the revisions and changes summarized above.

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Acknowledgment is made and appreciation expressed to Harry Hayes, Assistant Sanitary Engineer, Department of Water and Power, Los Angeles, and to the Manufacturers Technical Advisory Committtee to AWWA Committee 8310 D, for their assistance and cooperation in the preparation of these specifications.

Table of Contents

AWWA C203-57

(*Formerly* C203 & C204)

Standard Specifications for

Coal-Tar Enamel Protective Coatings for Steel Water Pipe

Section 1—General

Sec. 1.1—Purpose

These specifications cover the material and application requirements for coal-tar enamel protective coatings for steel water pipe to be installed under normal or average construction conditions in any soils, or aboveground.

An Appendix has been added to these specifications to provide additional exterior protective measures for steel water pipe to be installed under unusual construction conditions—such as submarine lines, casing pipe, and river crossings—and in exceptionally rocky areas.

The purchaser, when inviting bids, shall specify his requirements for protective coating by referring to the designation of these specifications and to the section and subdivision of the Appendix for the type of additional protection if such be required. In addition, the purchaser shall supply certain detailed information covering each individual contract in accordance with Sec. 1.3 of these specifications.

Sec. 1.2—Scope

Corrosion protection as provided under these specifications is as follows:

1.2.1. *For the inside of all pipe,* a coat of coal-tar primer followed by a hot coat of coal-tar enamel applied either by manual or mechanical means.

1.2.2. *For the outside of all pipe less than 30 in. in diameter to be placed underground,* a coat of coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded a single layer of asbestos felt wrap, and finished with one coat of water-resistant whitewash or a single wrap of kraft paper as outlined in the Appendix.

1.2.3. *For the outside of all pipe 30 in. in diameter and larger to be placed underground,* a coat of coal-tar primer followed by a hot coat of coal-tar enamel and one coat of water-resistant whitewash. If the purchaser desires a layer of asbestos felt wrap as outlined in the Appendix, he shall so state in the call for bids.

1.2.4. *For the outside of all pipe to be placed aboveground* exposed to the weather, two coats of synthetic red lead primer (or one coat of synthetic red lead primer and one coat of synthetic white enamel) and one coat of aluminum paint.

1.2.5. *For the outside of all pipe to be placed aboveground and exposed to more corrosive than normal conditions,* such as in coastal or industrial areas, one coat of coal-tar primer (if blasted before erection), one coat of heavy-bodied coal-tar coating (cold applied), one coat of heavy-bodied coal-tar emulsion, and one coat of aluminum paint. The coat of coal-tar primer is to be eliminated if the surfaces are blasted after erection.

Sec. 1.3—Supplementary Details Which Shall Be Supplied by the Purchaser

1.3.1. Where a steel pipeline is to be laid under conditions ordinarily found in water transmission and distri-

bution systems, reference to the specifications shall be as follows:

(1) *For pipe less than 30 in. in diameter:*

The interior surface of all steel pipe shall be cleaned, primed, and lined with coal-tar enamel, and the exterior shall be cleaned, primed, and coated with coal-tar enamel with a *bonded* asbestos felt wrapper. All such materials and application shall be in accordance with American Water Works Association Specifications C203, together with Sec. A1.2 and A3.1 of the Appendix of those specifications.

(2) *For pipe 30 in. in diameter and over:*

The interior surface of all steel pipe shall be cleaned, primed, and lined with coal-tar enamel, and the exterior shall be cleaned, primed, and coated with coal-tar enamel. All such materials and application shall be in accordance with American Water Works Association Specifications C203.

1.3.2. If additional exterior protection is desired, in the opinion of the engineer, because of extreme soil conditions or on submarine lines, river crossings, etc., the engineer shall designate in his specifications one of the alternate types of exterior protection, provided in the Appendix. The following *example* illustrates how such specifications should be written:

The interior surface of all steel pipe shall be cleaned, primed, and lined with coal-tar enamel, and the exterior shall be cleaned, primed, and coated with coal-tar enamel and wrapped with bonded double asbestos felt wrappers. All such materials and application shall be in accordance with American Water Works Association Specifications C203, together with Section (A1.3 *) of the Appendix of those specifications.

1.3.3. In purchasing protection for steel water pipe, the purchaser shall make supplementary specific statements in his specifications regarding the following:

(1) *Project.* Diameter, length, and location of pipeline, including maps and drawings necessary to show all details of line within the scope of the contract.

(2) *Temperatures.* Range of atmospheric temperatures to which the pipe may be subjected during, or subsequent to, installation.

(3) *Exterior protection—underground.* Length of line to be protected for underground service.

(4) *Exterior protection—aboveground.* Length of line to be erected aboveground for normal atmospheric service; and length of line to be erected aboveground where more corrosive conditions exist.

(5) *Contractor's samples.* Requests for contractor's samples in accordance with Sec. 2.3 of these specifications.

(6) *Materials.* When "corrosion protection" outlined here is to be done by force account or by separate contract, specify:

a. Quantity of coal-tar primer.

b. Quantity and type or types of coal-tar enamel.

c. Quantity of asbestos felt.

d. Quantity of fibrous glass mat.

e. Quantity of paint or exposed steel surfaces:

(i) Synthetic red lead primer.

(ii) Synthetic white enamel.

(iii) Aluminum bronzing liquid.

(iv) Aluminum pigment.

(v) Cold-applied coal-tar coating.

(vi) Cold-applied coal-tar emulsion.

Sec. 1.4—Definitions

Under these specifications the following definitions will apply:

1.4.1. *Purchaser.* The word "purchaser" shall mean the person, firm, corporation, or governmental subdivision entering into a contract or agreement for the purchase of any materials and/or any work to be performed under these specifications.

* Purchaser shall specify the type of exterior protection set forth in the Appendix.

1.4.2. *Contractor.* The word "contractor" shall mean the person, firm, or corporation executing the contract or agreement with the purchaser to furnish any material and/or to perform any work under these specifications.

1.4.3. *Inspector.* The word "inspector" shall mean the inspector or engineer employed by the purchaser and acting as his representative; their respective assistants properly authorized and limited to the particular duties assigned to them; or the purchaser, himself, acting as his own engineer.

1.4.4. *Blasting.* The word "blasting" shall mean blasting with standard sand-blasting sand or steel grit to clean and thoroughly remove all rust and mill scale from the steel.

1.4.5. *Centrifugal casting.* The words "centrifugal casting" shall mean the process of applying coal-tar enamel to the inside surface of pipe whereby molten coal-tar enamel introduced into the pipe is spread on the surface of the pipe and held thereon by the centrifugal force developed by rotating the pipe about its longitudinal axis until the coal-tar enamel has cooled and solidified and become bonded to the pipe.

Sec. 1.5—Inspection and Testing

1.5.1. The entire procedure of applying the protective coating material as herein specified will be rigidly inspected from the time the bare pipe is received until the coated pipe is laid in the ground and backfilled and/or installation of surface pipe is completed. Such inspection shall not relieve the contractor of his responsibility to furnish material and perform work in accordance with these specifications.

1.5.2. All coating work to be acceptable must be applied in the presence of the inspector, and all such work done in his absence will be subject to rejection unless the continuance of the work during his absence is specifically allowed by the inspector. If at any time it is found that the procedure of applying the protective coating material is not in accordance with these specifications, all such coating work may be rejected.

1.5.3. Prior to approval of contractor's material, samples of material submitted by the contractor will be tested by the purchaser and if any sample is found not to conform to these specifications, material represented by such sample will be rejected. If samples of contractor's approved materials are found not to conform to the specifications, all such material will be rejected.

1.5.4. Samples submitted to the purchaser will be tested in the purchaser's laboratory or in a responsible commercial laboratory designated by the purchaser.

1.5.5. The expense of testing of all samples of material originally offered by the contractor will be borne by the purchaser; the expense of all subsequent tests due to failure of samples of materials originally offered to comply with these specifications will be charged to the contractor.

Sec. 1.6—Access for Inspector

The inspector shall have free access to those parts of all plants that are concerned with the furnishing of materials or the performance of work under these specifications.

Sec. 1.7—Facilities for Inspector

The contractor shall furnish the inspector reasonable facilities and space without charge for the inspection, testing, and obtaining of such information as he desires respecting the character of material used and the progress and manner of the work.

Sec. 1.8—Material and Workmanship

All material furnished by the contractor shall be of the specified quality. All work shall be done in a thorough workmanlike manner. The entire operation of priming the pipe and heating and applying the coal-tar enamel coatings shall be performed under the supervision of and by experienced men skilled in the application of coal-tar enamel.

Sec. 1.9—Equipment

The contractor's equipment for all blasting, priming, enameling, and painting shall be designed and manufactured and shall be in such condition as to permit applicators to follow the procedure and obtain results prescribed in these specifications.

Sec. 1.10—Packaging

All coal-tar enamel and coal-tar primer and wraps purchased or used under these specifications shall be packaged in suitable and approved containers. The containers shall be plainly marked with the name of the manufacturer, type of material, and batch or lot number.

Section 2—Material Specifications

Sec. 2.1—Coal-Tar Primer

All coal-tar primer to be used under these specifications shall comply with the following:

2.1.1. The primer shall consist of processed coal-tar pitch and refined coal-tar oils only, suitably blended to produce a liquid coating which may be applied cold by brushing or spraying and which will produce an effective bond between the metal and subsequent coating of coal-tar enamel. Primer shall contain no benzol or other toxic or highly volatile solvents and no added pigments or inert fillers, or other substances, and shall show no tendency to settle out in the container.

2.1.2. The primer shall have good spraying and brushing properties and a minimum tendency to produce bubbles during application. The primer shall dry hard to the touch when applied as recommended.

Sec. 2.2—Coal-Tar Enamel

The type of enamel used shall be AWWA coal-tar enamel. This enamel shall be composed of a specially processed coal-tar pitch combined with an inert mineral filler. No asphalt of either petroleum or natural base shall be acceptable as part of the ingredients. The enamel shall have the characteristics shown in Table 1.

Sec. 2.3—Contractor's Samples and Detailed Information

2.3.1. When specified by the purchaser, the contractor shall submit to the purchaser for testing, prior to any work under these specifications, a 50-lb sample of the coal-tar enamel and a 1-qt sample of the coal-tar primer he proposes to furnish. Samples shall be taken from a production run of the manufacturer's plant. Samples shall be identified by batch or lot numbers. Contractor shall submit with the samples a certified copy of results of tests made by the manufacturer covering the physical and performance characteristics of the samples. This certificate shall indicate the coverage rate of the

TABLE 1

Characteristics of AWWA Coal-Tar Enamel

Test	Minimum	Maximum
Softening point—ASTM D36–26	220°F	—
Filler (ash)—ASTM D271–48	25%	35%
Fineness filler, through 200 mesh—ASTM D546–41	90%	—
Specific gravity at 25°C—ASTM D71–52	1.40	1.60
* Penetration—ASTM D5–52		
At 77° F—100-g weight—5 sec	10	20
At 115°F—50-g weight—5 sec	15	55
High-temperature test—at 160°F (sag)—AWWA C203, Sec. 2.4.4(1)	—	$\frac{3}{32}$ in.
Low-temperature test—at −20°F (cracking)—AWWA C203, Sec. 2.4.4(2)	—	none
† Deflection test (initial heating)—AWWA C203, Sec. 2.4.4(3)		
Initial crack	0.8 in.	—
Disbonded area	—	3.0 sq in.
† Deflection test (after heating)—AWWA C203, Sec. 2.4.4(4)		
Initial crack	0.6 in.	—
Disbonded area	—	5.0 sq in.
† Impact test—at 77°F—650-g ball, 8-ft drop—AWWA C203, Sec. 2.4.4(6)		
Direct impact—disbonded area	—	10.0 sq in.
Indirect impact—disbonded area	—	2.0 sq in.
Peel test—AWWA C203, Sec. 2.4.4(5)	no peeling	

* For anticipated minimum temperature exposures between 20° and −20°F, use enamels with penetration of 15 to 20 at 77°F.

† Choice of bond testing methods A or B by deflection (before heating), by deflection (after heating), or by impact shall depend upon laboratory equipment available.

primer in grams per square foot, the application temperature of the enamel, and the method of application of the enamel to the test plates.

2.3.2. Samples submitted to the purchaser will be tested in the purchaser's laboratory or in a responsible commercial laboratory designated by the purchaser.

2.3.3. The expense of testing of all samples of material supplied by the contractor will be borne by the purchaser.

2.3.4. After the contractor has obtained approval from the purchaser for the coal-tar enamel and coal-tar primer he proposes to furnish, the contractor shall submit the coating manufacturer's detailed specifications for the coal-tar enamel and coal-tar primer supplied for the project, with instructions for the handling and application of the material; this information shall include:

(1) Method of application of primer and coverage in square feet per gallon.

(2) Minimum and maximum drying time of the primer before application of enamel.

(3) Application temperature of enamel.

(4) Maximum allowable temperature to which enamel may be heated.

(5) Maximum time enamel may be held in heating kettles at application temperature.

2.3.5. Contractor will be required to furnish the purchaser with a certified copy of results of tests made by the manufacturer covering physical and performance characteristics of each batch of enamel and primer to be sup-

plied under these specifications. When requested by the purchaser, the contractor shall furnish or allow the purchaser to collect samples of the material representative of each batch of enamel and/or primer. Certified test reports and samples furnished by the contractor shall be properly identified to each batch of enamel and/or primer.

Sec. 2.4—Test Procedure for Primer and Enamels

Tests to determine physical characteristics of enamel and primer furnished by the contractor or collected by the purchaser shall be in accordance with the American Society for Testing Materials Standard Designations as indicated in Sec. 2.2 (Table 1) of these specifications. The preparation of test specimens and the testing for performance characteristics by methods other than ASTM procedures shall be in accordance with the following procedure:

2.4.1. *Preparation of test plates.* All performance tests shall be made on steel plates free of all oil and grease. One side of each plate shall be blasted to a uniform steel gray surface, completely removing rust, mill scale, and all other foreign matter. For blasting, a sharp, dry sand having a minimum of 50 per cent retained on a 60-mesh screen or a No. 50 steel grit shall be used with an air pressure of not less than 75 psi.

2.4.2. *Priming test plates.* All test plates shall be freshly prepared as specified in Section 2.4.1 and shall be primed using 5.0–9.0 g per square foot.* The primer shall be applied with a new, clean, flat bristle brush of 1-in. width. Plates shall be primed and dried while lying horizontally in a well ventilated room under the following conditions:

(1) Temperature— minimum 70°F, maximum 90°F.

(2) Relative humidity—maximum 60 per cent.

(3) Enamel shall be applied after 16 hr, but not later than 72 hr after the primer has been applied.

2.4.3. *Preparation of enamel for testing.* Thirty pounds of enamel broken into pieces approximately 4 in. in maximum dimension shall be rapidly melted over a large gas burner in a metal container of uniform cross section not less than 8 in. nor more than 12 in. in diameter. Immediately upon reaching the specified application temperature, the enamel shall be applied to the primed test plates required for high-temperature and low-temperature performance, Method A or Method B; deflection test (initial heating), Method A; peel test; and impact test, Method B. The remaining enamel in the container, which shall be not less than 20 lb, shall be maintained at the recommended application temperature for a 2-hr period. The enamel shall be stirred with a metal bar at intervals of 15 min during the heating period. A $\frac{1}{4}$-in. steel plate shall be interposed between the container and gas flame to avoid superheating. After the 2-hr heating period, this enamel shall be applied to the test plates required for "Deflection test (after 2-hr heating)," Method A. The application temperatures and method of application shall be as recommended by the coating manufacturer. The enamel shall be applied to a thickness of $\frac{2}{32}$ to $\frac{3}{32}$ in. for all test plates.

2.4.4. *Testing procedure.* Depending on the laboratory equipment avail-

* The testing laboratory shall follow specific recommendations of the manufacturer for coverage rate of primer to be applied to test plates.

able, either Method A or Method B shall be used for the following tests:

(1) *High-temperature test:*

a. Method A. Two $12 \times 4 \times \frac{3}{16}$-in. plates prepared as above, on which shall be scribed three lines at 3-in. intervals across the enamel surface, shall be tested as directed under "Procedure."

b. Method B. Two $12 \times 12 \times \frac{7}{64}$-in. plates prepared as above with a $\frac{1}{2}$-in. uncoated border left around the four edges of the plates, on which shall be scribed lines 1 in. apart across the face of the enamel and continued on the uncoated surface of the plate to the edges, shall be tested as directed under "Procedure."

c. Procedure. The plates as prepared for Method A or Method B shall be stored in a vertical position in a chamber the temperature of which shall be controlled for 24 hr at 160°F. At the end of this period the plates shall be removed and cooled to room temperature, and the average sag of the lines on the two plates shall be recorded as sag of the enamel.

(2) *Low-temperature test.* After the two plates, prepared as in Method A or Method B, have been used in the above test, they shall be placed in a chamber the temperature of which shall be controlled for a 6-hr period at −20°F. At the end of this period the plates shall be removed and allowed to reach room temperature, then examined for evidence of cracking and/or disbonding of the enamel.

(3) *Deflection test (initial heating).* Four plates, $10 \times 4 \times \frac{1}{16}$ in., prepared as above for testing under Method A, shall be stored in a chamber the temperature of which shall be controlled at 40°F. After a 6-hr period the plates shall be tested for deflection on equipment in this chamber by supporting the plates on $\frac{1}{8}$-in. radius knife edges which are spaced on $9\frac{1}{2}$-in. centers. The deflecting load shall be centrally applied across the plate by a $\frac{1}{2}$-in. radius mandrel at the rate of 1 in. per minute (to produce tension in the enamel) until cracking occurs, as indicated by an electrical holiday detector. The deflection producing the initial cracking shall be recorded, and the deflection shall then be continued to a maximum distance of $1\frac{1}{2}$ in. The specimen shall then be removed from the machine for examination. All disbonded enamel shall be removed from the plate, and the area of metal exposed on the four plates shall be measured. The average results of initial cracking and disbonded area shall be recorded.

(4) *Deflection test (after 2-hr heating).* Four plates, $10 \times 4 \times \frac{1}{16}$ in., prepared as above for testing under Method A shall be used in this test. The procedure shall be the same as described in Sec. 2.4.4(3) above, and the average results of initial cracking and disbonded area shall be recorded.

(5) *Peel test.* Two plates, $12 \times 12 \times \frac{1}{2}$ in., shall be prepared as above for testing enamel. After the application of enamel the plates shall be allowed to cool to room temperature. (Tolerance of ± 2°F will be allowed on all temperature requirements listed below.)

a. Bond, initial. One test plate shall be tested directly. The condition of bond shall be tested over a temperature range of 80°–160°F at successive intervals of 20°F—that is, 80°, 100°, 120°, 140°, 160°F. The test shall be made at the temperatures indicated by immersing the plates for a period of approximately $\frac{1}{2}$ hr in a water bath maintained at the selected temperature. At the end of each of these periods the plate shall be removed from the bath

and immediately tested for peel. This shall be done as follows: With a knife edge, cut two parallel lines through the enamel approximately $\frac{3}{4}$ in. apart and approximately 4 in. in length. With the edge of the knife blade, cut under the enamel strip at one end and loosen the enamel from the plate the full width of the strip for about $\frac{1}{2}$ in. Place the knife blade under the loosened end, and with a firm grip apply a slow, steady pull upward on the enamel strip. Adhesion of the enamel at each of the indicated test temperatures, to the extent of preventing peeling, stripping, or lifting of not more than $\frac{1}{8}$ in., shall be recorded as no peeling. The use of the water bath for the 80°F test may be omitted when the room temperature closely approximates 80°F.

b. Bond, after 72 hr at 160°F. The second test plate shall be stored in a horizontal position, with the enameled side up, in a chamber the temperature of which shall be controlled for 72 hr at 160°F. At the end of this period the plate shall be removed and cooled to room temperature and tested for condition of bond over a temperature range of 80°–160°F as above.

(6) *Impact test.* The $12 \times 12 \times \frac{7}{64}$-in. plates, prepared as above and used under test procedures in Sec. 2.4.4(1) and 2.4.4(2) under Method B, shall be allowed to reach room temperature and then shall be immersed in a water bath held at a uniform temperature of 77°F for a period of at least 1 hr before testing. Each plate shall be removed from the water bath, dried with a soft clean cloth, and immediately subjected to the impact test.

a. Direct impact. Each plate shall be supported on the true plane surface of a block of wood. A 650-g steel ball with a well polished spherical surface shall be dropped from a height 8 ft above the surface of the plate when testing enamel. The ball shall be dropped so as to strike the enamel at a point at least 4 in. from any edge of the plate. After one such impact, the enamel shall be examined for evidence of shattering and loosening from the plate.

b. Indirect impact. After being subjected to direct impact, plates shall be placed with the coated face down on a wooden block through which a $3\frac{1}{2}$-in. diameter hole has been cut. The same ball shall then be dropped from a height of 8 ft above the surface of the plate, so as to strike the steel plate at a point over the center of the hole in the wooden support block. The point of impact shall be at least 4 in. from any edge of the plate and shall be at least 3 in. from the point of direct impact. After one such impact, the enamel shall be examined for evidence of shattering and loosening of the coating. Coating that has been knocked off the plate by the impact of the steel ball shall be considered as shattered coating. Loose coating is coating that has not been shattered but can be easily and readily removed from the plate by the fingers or, with very little force, by the use of a knife blade or similar instrument. After removal, the area of loosened coating shall be determined.

Sec. 2.5—Whitewash Formula

All whitewash to be used shall be mixed as follows:

2.5.1. *Ingredients:*

50 gal water.
1 gal boiled linseed oil.
150 lb processed quicklime.
10 lb salt.

2.5.2. *Mixture.* Lime and oil shall be slowly added simultaneously to the water and mixed thoroughly. The

mixture shall be allowed to stand for not less than 3 days before it is used.

Sec. 2.6—Synthetic Red Lead Primer

The paint to be used for the first and second exterior coats on steel structures erected aboveground shall comply with the following:

2.6.1. The red lead primer shall be a ready mixed paint composed of red lead pigment and synthetic-resin vehicle well ground together to produce a liquid coating which may be applied by brushing or spraying and which will dry rapidly and provide a suitable bond between the metal and subsequent coating of paint. The primer shall contain no benzol or other toxic solvent and shall show no tendency to jell or liver in the container.

2.6.2. The primer shall possess the following physical characteristics:

(1) Viscosity at 77°F—30–50 sec Gardner Mobilometer (Solid Plunger) 150-g total weight, 10-cm drop.

(2) Weight per gallon—20–22 lb (ASTM D287–53T).

(3) Dry red lead (97 per cent Pb_3O_4)—minimum 70 per cent by weight.

(4) Varnish vehicle (synthetic-resin type)—maximum 30 per cent by weight.

2.6.3. The vehicle shall be a synthetic-resin varnish consisting of either an alkyd or phenol-formaldehyde resin with the necessary vegetable oils and volatile thinners to produce elasticity, waterproofness, adherence, and durability in the finished paint film.

2.6.4. The red lead primer shall have satisfactory working properties, defined as follows:

The red lead primer shall be readily broken up with a paddle to a smooth, uniform paint suitable for brushing or spraying with the addition of not more than 10 per cent, by volume, of a suitable nontoxic thinner. The red lead primer applied by either method shall have good self-leveling properties, both of the vehicle and of the pigment, and, when brushed or sprayed on a vertical surface at a coverage rate of 500 sq ft per gallon, shall dry hard and elastic without running, streaking, or sagging. The drying properties shall be such that the primer film will dry dust free and free to touch in 1 hr, and dry to a smooth, hard film in 6 hr. The primer film produced shall have a flat or semigloss finish after 24-hr drying.

2.6.5. Red lead primer shall be packaged in iron pails of 5-gal maximum capacity.

Sec. 2.7—Synthetic White Enamel

When pipe to be erected aboveground is installed during hot weather, the second coat of primer shall be synthetic white enamel in place of synthetic red lead primer. Synthetic white enamel shall comply with the following:

2.7.1. The synthetic white enamel shall be a ready mixed paint composed of titanium oxide pigment and alkyd resin vehicle well ground together to produce a liquid coating which may be applied readily by brushing or spraying, which dries rapidly, and which provides a suitable bond with the synthetic red lead primer over which it is applied. The white enamel shall contain no benzol or other toxic solvent and shall have a minimum tendency to settle out the pigment in the container. The composition of the paint shall be as follows:

Pigment (100 per cent titanium oxide)—25 per cent.

Varnish vehicle (alkyd resin type)—75 per cent.

2.7.2. The vehicle shall be of the alkyd resin type and shall contain 40

per cent nonvolatile solids. The volatile constituents shall be 70 per cent coal-tar hydrocarbon solvents and 30 per cent high-flash naphtha.

2.7.3. The synthetic white enamel shall have satisfactory working properties, defined as follows:

The white enamel shall be readily broken up with a paddle to a smooth, uniform paint suitable for brushing or spraying with the addition of not more than 10 per cent, by volume, of a suitable nontoxic thinner. The white enamel as applied by either method shall have good self-leveling properties and, when brushed or sprayed on a vertical surface at a coverage rate of 500 sq ft per gallon, shall dry hard and elastic without running, streaking, or sagging. The drying properties shall be such that the paint film will dry dust free and free to touch in 1 hr, and dry to a smooth, hard film in 24 hr. The film when dried shall show a strong tendency to chalk on the surface when exposed to the weather.

Sec. 2.8—Aluminum Bronzing Liquid

2.8.1. The vehicle for aluminum paint shall be composed of treated oils, resins, metal driers, and volatile thinners. Treated oils shall be manufactured from the highest grade of spar varnish and linseed and chinawood oils. Resins employed shall be the so-called synthetic type, representing three distinct types, which shall perform the double duty of setting and drying the oil film through in the shortest possible time and increasing the resistance of the film to acids and alkalis and weathering. Solvents shall be a mixture of turpentine, coal-tar, and petroleum thinners designed to evaporate just rapidly enough to promote the proper speed of drying without impairing the working qualities of the vehicle and shall be of proper blend required to produce the maximum floating of the aluminum bronze.

2.8.2. The vehicle shall conform to the following tests:

(1) *Appearance.* Clear and transparent.

(2) *Color.* Not darker than Tube No. 14 of Gardner Color Standards for Varnishes and Lacquers.

(3) *Flash point.* Not below 86°F.

(4) *Nonvolatile matter.* Not less than 50 per cent by weight.

(5) *Viscosity at 77°F*—0.5–1.0 poises (Tubes A to D, Gardner-Holt Standards).

Test procedure is indicated in ASTM D154–53.

2.8.3. The vehicle shall have the following physical properties:

(1) Set to touch in not more than 3 hr at 70°F, 65 per cent relative humidity.

(2) Dry hard in not more than 24 hr at 70°F.

(3) When mixed with aluminum bronzing pigment in the ratio of 2 lb of pigment to 1 gal of vehicle, the resulting paint shall have good flowing, covering, and leveling properties, with the ability to float aluminum bronze flakes to the surface uniformly without allowing the bronze to break or separate before setting. The paint shall be readily applicable by air spray gun methods and, when applied to a vertical steel surface at the coverage rate of 300–400 sq ft per gallon, the paint film so applied shall dry without running, streaking, sagging, or wrinkling. The paint when dry shall have high light reflective properties.

Sec. 2.9—Aluminum Bronzing Pigment

The aluminum bronzing pigment shall conform to one of the following

Federal Specifications for the respective grades designated:

2.9.1. Standard Varnish Grade Powder—Federal Specifications TT-A-476, Type A.

2.9.2. Standard Paste—Federal Specifications TT-A-466.

Sec. 2.10—Cold-applied Coal-Tar Coating

The cold-applied coal-tar coating to be used for the first exterior coat on steel structures erected aboveground and exposed to more severe corrosive conditions shall comply with the following:

The cold-applied coal-tar coating shall be composed of a specially processed coal-tar pitch blended with selected solvents to a heavy consistency. No asphalt of either petroleum or natural base shall be acceptable as part of the ingredients. This coating shall conform to AWWA Specifications D102, Sec. 5.4.5.

Sec. 2.11—Cold-applied Coal-Tar Emulsion

The cold-applied coal-tar emulsion to be used for the second exterior coat on steel structures erected aboveground and exposed to more severe corrosive conditions shall comply with the following:

This thick, heavy-duty, cold-applied coal-tar emulsion shall be composed of a base derived from coal tar and inert mineral filler dispersed in water to produce a stable colloidal suspension. No asphalt of either petroleum or natural base shall be acceptable as part of the ingredients. The emulsion shall conform to Federal Specifications MIL-C-15203-A.

Section 3—Shop Application of Coal-Tar Primers and Enamels

Sec. 3.1—General

The contractor shall furnish all labor, equipment, and material required, shall prepare all surfaces to be coated, and shall apply the coal-tar primer and coal-tar enamel to all interior and exterior surfaces to be coated.

Sec. 3.2—Preparation of Surfaces

3.2.1. Before blasting, all oil and grease on the surfaces of the metal shall be removed thoroughly by flushing and wiping, using "Xylol," or other suitable coal-tar base solvents, and clean rags. The use of dirty or oily rags or solvent will not be permitted. All other foreign matter not removable by blasting shall be removed by suitable means. All metal surfaces shall be thoroughly cleaned by blasting. Blasted surfaces that rust before a priming coat has been applied shall be cleaned of all rust by buffing or wire-brushing or, at the discretion of the engineer, shall be reblasted. Adequate air separators shall be used to remove effectively all oil and free moisture from the air-supply to the blaster.

3.2.2. After cleaning, the pipe shall be protected from and maintained free of all oil, grease, and dirt that might fall upon the pipe from whatever source until it has received its final enamel coat. Any pipe showing pits after beginning of blasting shall be set aside immediately, pending examination by the engineer for approval, reconditioning, or rejection.

Sec. 3.3—Coal-Tar Priming

The coal-tar primer shall be as specified in the paragraphs under Sec. 2.1 of

these specifications, and the application shall be as follows:

3.3.1. All blasted steel surfaces shall be cleaned of dust and grit and shall be ***primed immediately following blasting and cleaning.*** The surfaces shall be dry at the time the coal-tar primer is applied, and no primer shall be applied during rain or fog unless protected from the weather by suitable housing.

3.3.2. At the option of the contractor, the application of the primer shall be by hand brushing, air gun spraying, or spraying-and-brushing, and shall be in accordance with instructions for application as supplied by the manufacturer of the primer. The apparatus to be used for application of the primer shall be approved by the engineer. Spray gun apparatus to be used shall include a mechanically agitated pressure pot and an air separator that will remove all oil and free moisture from the air supply.

3.3.3. The use of coal-tar primer that becomes fouled with foreign substances or has thickened through evaporation of the solvent oils will not be permitted.

3.3.4. After application, the coal-tar priming coat shall be uniform and free from floods, runs, sags, drips, holidays, or bare spots. Any bare spots or holidays shall be recoated with an additional application of primer. All runs, sags, floods, or drips shall be removed by scraping and cleaning and the cleaned area retouched, or, at the discretion of the engineer, all such defects shall be remedied by reblasting and repriming. Suitable measures shall be taken to protect wet primer from contact with rain, fog, mist, spray, dust, or other foreign matter until completely hardened and enamel applied.

3.3.5. In cold weather when the temperature of the steel is below 45°F, or at any time when moisture collects on the steel, the steel shall be warmed to a temperature of approximately 85°–100°F for sufficient time to dry the pipe prior to priming. To facilitate spraying and spreading, the primer may be heated and maintained during the application at a temperature of not more than 120°F.

3.3.6. The minimum and maximum allowable drying time of the coal-tar primer between application of primer and application of coal-tar enamel shall be in accordance with instructions issued by the manufacturer of the primer unless otherwise directed by the engineer. If the enamel is not applied within the maximum time after priming, as required by the manufacturer or as directed by the engineer, the pipe shall be reprimed with an additional light coat of primer, or, at the discretion of the engineer, the entire prime coat shall be removed by reblasting and the pipe reprimed.

Sec. 3.4—Preheating of Primed Pipe

3.4.1. At all times during cold weather when pipe temperature is below 45°F, or during rainy or foggy weather when moisture tends to collect on cold pipe, enameling shall be preceded by warming the pipe.

3.4.2. Warming shall be done by any method which will heat pipe uniformly to recommended temperature without injury to primer. Steel temperature of pipe shall not exceed 160°F.

3.4.3. After heating and while pipe is at its highest temperature, inside lining enamel shall be applied. Coating of the outside of the pipe with coal-tar enamel shall proceed immediately after the spinning operation is completed, while the pipe is still warm from preheating and centrifugal casting.

3.4.4. The same procedure shall apply for pipe primed on the outside with

synthetic red lead primer, except that the second coat of paint need not be applied while the pipe is warm.

Sec. 3.5—Coal-Tar Enamel Application

The type of coal-tar enamel to be used for the interior lining and the exterior coating shall be in accordance with Sec. *2.2* of these specifications. The application shall be as follows:

3.5.1. The enamel shall be heated in approved heating kettles equipped with accurate and easily read thermometers. In addition, the purchaser reserves the right to provide recording thermometers; such thermometers shall be installed on the heating kettles as directed by the engineer and at the expense of the contractor. Such thermometers will be checked and adjusted by the engineer whenever necessary. The charts therefrom shall constitute a basis for acceptance or rejection of any enamel because of improper heating and/or handling.

3.5.2. The operating and/or supply kettles shall be provided in sufficient numbers so that the enamel may be heated and coordinated with the application procedure. No enamel shall be held in the operation kettles at application temperatures for a longer period than recommended by the manufacturer or stated in his instructions. The enamel heated in supply kettles shall not exceed the temperatures and melting periods recommended by the coating manufacturer. Operating kettles shall not be used as a continuous source of supply by adding unmelted enamel during the time they are in use but shall be completely emptied of one charge and cleaned, if necessary, before the next charge of unmelted enamel is added; except when mechanically agitated kettles are used. In the practice of field patching, the engineer may permit continuous use of a heating kettle not exceeding 50-gal capacity. Kettles shall be covered with hinged lids which may be securely fastened down and shall be tightly closed during the heating and application of enamel except for neceessary loading and stirring.

3.5.3. The enamel shall be maintained moisture and dirt free at all times prior to, and at the time of, heating and application.

3.5.4. In loading the kettles, the enamel shall be broken into pieces suitable for the heating equipment used.

3.5.5. In heating the enamel, the charge shall be melted and brought up to application temperature as rapidly as possible without injury to the enamel. The temperature at which the enamel will be applied shall be in accordance with the recommendation furnished by the manufacturer. The hot enamel shall be thoroughly stirred at intervals not exceeding 15 min regardless of whether the enamel is being used from kettles or is being held ready for use. Iron paddles shall be used for stirring; wooden paddles will not be permitted.

3.5.6. The maximum allowable temperature to which enamel may be heated and the maximum allowable time that the enamel may be held in the kettles at application temperature shall be in accordance with the instructions supplied by the manufacturer.

3.5.7. Enamel that has been heated in excess of the maximum allowable temperature, or that has been held at application temperature for a period in excess of that specified, shall be condemned and rejected. Fluxing the enamel will not be permitted.

3.5.8. Excess enamel remaining in a kettle at the end of any heat shall not be included in a fresh batch in an amount greater than 10 per cent of the batch. Kettles shall be emptied and cleaned frequently as required. The material removed in cleaning the kettles shall be dumped and wasted.

Sec. 3.6—Application of Coal-Tar Enamel to Interior Surfaces

3.6.1. The primed steel surface to be enameled shall be dry and clean at the time the enamel is applied. No enamel shall be applied during cold weather, rain, or fog unless the pipe is preheated and/or protected by suitable housing.

3.6.2. The application of the enamel to the inside surface of all pipe other than specials shall be by centrifugal casting by either the Trough Method (Sec. 3.7 of these specifications) or the Retracting-Weir or Feed Line Method (Sec. 3.8 of these specifications).

3.6.3. During application of enamel, the pipe shall be revolved at the speed best suited to produce a smooth, glossy lining of uniform thickness. Finished coal-tar enamel lining shall be free from wrinkles, sags, blisters, or blowholes. Thickness of lining shall be $\frac{3}{32}$ in., and the allowable variations in thickness shall not exceed $\pm\frac{1}{32}$ in. All pieces of lined pipe in which excessive rough areas appear or other irregularities unsatisfactory to the engineer exist shall be stripped of the entire lining and relined as herein required for original lining.

3.6.4. All kettles shall be equipped with adequate screens to prevent particles of foreign matter or other deleterious materials from appearing in the finished coating.

3.6.5. Water used for chilling the enamel lining following centrifugal casting shall not be applied until the enamel has hardened sufficiently to prevent water marks.

Sec. 3.7—Centrifugal Casting of Coal-Tar Enamel by the Trough Method

3.7.1. Pipe shall be rotated on rubber-tired or steel wheels with suitable guards to prevent the pipe from leaving the rolls during spinning operations.

3.7.2. Molten enamel shall be introduced into the pipe by a pouring trough extending the full length of the pipe in either one or two sections. The pouring trough shall be level and shall have a straight and even pouring lip. The trough may be heated either by electrical heating elements or by a gas flame to a temperature best adapted to the equipment available.

3.7.3. Transfer of molten enamel from kettles to pouring troughs shall be conducted in such a manner as to prevent excessive loss of heat. Hot enamel shall be held in the pouring troughs between filling and pouring for not more than 1 min. Enamel shall not be poured from troughs into the pipe until the pipe has reached its maximum speed of rotation.

3.7.4. Enamel shall be poured by inverting the trough with a uniform rotation and at such speed as to distribute the enamel evenly throughout the pipe.

3.7.5. Immediately after the pouring operations, the trough shall be righted and removed from the pipe and cleaned, when necessary, of all excess enamel remaining in the trough. Such enamel may be reused, if it is clean and free of dirt, by adding to fresh batches in quantities not exceeding 10 per cent of unmelted enamel.

Sec. 3.8—Centrifugal Casting of Coal-Tar Enamel by the Retracting-Weir or Feed Line Method

3.8.1. Pipe shall be rotated on rubber-tired wheels with suitable guards or holddown wheels to prevent the pipe from leaving the rolls during spinning operations.

3.8.2. The hot enamel shall be introduced into the rotating pipe by means of a retractable feed line or over a traveling weir whose pouring lip is parallel to the longitudinal axis of the pipe. In either case, the discharge element of the supply mechanism shall travel the entire length of the pipe. The speed of travel shall be properly coordinated with the speed of rotation to insure complete multiple application of the molten enamel.

3.8.3. Molten enamel shall be supplied to the weir or feed line from a reservoir through supply pipes and maintained at application temperature by means of insulation and by the use of suitable methods of heating both reservoir and supply line. Supply of enamel shall be by means of a power-driven circulation pump.

Sec. 3.9—Application of Coal-Tar Enamel to Exterior Surfaces

3.9.1. The primed steel surface to be enameled shall be dry and clean at the time the enamel is applied. Any damage occurring to the primer coat shall be repaired by retouching before application of the enamel.

3.9.2. External enamel shall be applied by pouring on the revolving pipe and spreading to the specified thickness. Enamel shall be applied so that each spiral resulting from the spreading operations shall overlap the preceding spiral, producing a continuous coat free from defects. The thickness of coating shall be $\frac{3}{32}$ in., and the allowable variation in thickness shall not exceed $\pm \frac{1}{32}$ in.

3.9.3. The enameled pipe shall not be rolled or supported on its enameled surface until thoroughly cooled and hardened.

3.9.4. For application to specials and other shapes, see Sec. 3.11 of these specifications.

Sec. 3.10—Application of Coal-Tar Enamel at End of Pipe Sections

3.10.1. When pipe sections are to be joined together by field welding or riveting, the protective materials shall be left off the inside and outside surfaces at the ends a distance sufficient to permit the making of field joints without injury to the lining and coating.

3.10.2. When pipe sections are to be joined together with mechanical couplings, the enamel shall be left off the exterior of the pipe a distance back from the ends of 1 in. more than one-half the overall length of the assembled coupling. The interior enamel lining shall extend to the pipe end.

3.10.3. For joints other than specified herein, the length of pipe to be left bare at ends shall be in accordance with instructions supplied by the engineer.

Sec. 3.11—Specials—Cleaning, Lining, and Coating

The results of cleaning, lining, and coating of specials shall be equivalent to the results of similar work on straight pipe sections. Methods deviating from the prescribed procedure shall require approval by the engineer. If the shape precludes spinning, the lining and exterior coating shall be applied by hand daubers as follows:

3.11.1. All surfaces shall be double coated by applying the enamel with hand daubers. The brush strokes of

enamel shall be made in the direction of flow. All brush strokes shall overlap and form a continuous coating. The daubing may be done by the double-lap or "shingling" method. The work shall be done in a workmanlike manner, and no indiscriminate smearing of the enamel will be permitted. On all welds the strokes of the first coat of enamel shall be applied along the weld.

3.11.2. Enameling buckets shall be filled from the heating kettles with ladles or from spigots attached to the kettles and shall not be dipped for filling. Buckets shall be kept clean and free of dirt at all times and shall not be set directly upon the ground or on enameled surfaces but shall be set upon suitable pads or blocks. Buckets shall not be allowed to accumulate excess chilled enamel but shall be kept clean.

3.11.3. Enamel shall not be used from the enameling buckets below the minimum temperature specified by the manufacturer.

3.11.4. All drips and splashes of enamel on primed surfaces shall be carefully scraped off before the hand-brushed coat of enamel is applied. This pertains particularly where overhead hand enameling is necessary inside of pipe or specials.

3.11.5. Hand-enameling daubers shall be of the size best adapted for the work and shall be subject to the approval of the engineer. Daubers shall be made of the best grade of Tampico Fiber set in solid hardwood handles. Mops, sweeps, or knot daubers shall not be used. Long hand horseshoe daubers will be acceptable for large areas and flat work.

Sec. 3.12—Fittings

All fittings such as manholes, service connections, air valves, and blowoff connections shall be protected with coal-tar primer and coal-tar enamel, and the same application procedure shall be employed as specified under Sec. 3.11 of these specifications.

Sec. 3.13—Electrical Inspection

The contractor shall conduct electrical inspection of all of the coating by means of an approved electrical flaw detector delivering approximately 8,000–10,000 v at low amperage. Before final shop acceptance of coal-tar enamel coating, the entire interior and exterior surfaces of all coated pipe shall be tested, and all defects found shall be satisfactorily repaired by and at the expense of the contractor.

Sec. 3.14—Use of Whitewash on Exterior

Outside surfaces of all pipe and specials shall be given a coat of water-resistant whitewash immediately following final inspection.

Section 4–Field Procedure and Enameling

Sec. 4.1—Transporting and Handling Enameled Pipe

4.1.1. Protected pipe at all times shall be handled with equipment such as stout, wide belt slings and wide padded skids designed to prevent damage to the coating. Bare cables, chains, hooks, metal bars, or narrow skids shall not be permitted to come in contact with the coating. All handling and hauling equipment shall be approved by the engineer before use.

4.1.2. When shipped by rail, all pipe shall be carefully loaded on properly padded saddles or bolsters. All bearing surfaces and loading stakes shall be

properly padded with approved padding materials. Pipe sections shall be separated so that they do not bear against each other, and the whole load must be securely fastened together to prevent movement in transit. When applicable to this type of pipe, the pipe shall be loaded and tied into a unit load in strict accordance with the current loading rules of the American Railway Association.

4.1.3. In truck shipments, the pipe shall be supported in wide cradles of suitably padded timbers hollowed out on the supporting surface to fit the curvature of pipe, and all chains, cables, or other equipment use for fastening the load shall be carefully padded. For smaller-diameter pipe, sand- or sawdust-filled bags may be used instead of hollowed-out timbers.

4.1.4. The purchaser shall inspect the pipe and pipe protection on cars or trucks at destination, and if the pipe or pipe protection is found damaged, claim shall be made against the carrier.

Sec. 4.2—Handling Enameled Pipe in Field or at Trench

4.2.1. Pipe shall be stored along the trench side, supported on wooden timbers placed under the uncoated ends to hold the pipe off the ground.

4.2.2. Pipe shall be hoisted from the trench side to the trench by means of a wide belt sling. Chains, cables, tongs, or other equipment likely to cause damage to the enamel coating will not be permitted, nor will dragging or skidding the pipe. The contractor shall allow inspection of the coating on the under side of the pipe while suspended from the sling. Any damage shall be repaired before lowering the pipe into the trench.

4.2.3. Where the trench traverses rocky ground or ground containing hard objects that would penetrate the protective coating, a layer of screened earth or sand not less than 3 in. in thickness shall be placed in the bottom of the trench prior to installation of pipe.

4.2.4. At all times during erection of the pipeline the contractor shall use every precaution to prevent damage to protective coating on the pipe. No metal tools or heavy objects shall be unnecessarily permitted to come in contact with the finished coating. Workmen will be permitted to walk upon the coating only when necessary, and in case of such necessity the workmen shall wear shoes with rubber or composition soles and heels. This shall apply to all surfaces, whether bare, primed, or enameled. Any damage to the pipe or the protective coating from any cause during the installation of the pipeline and before final acceptance by the purchaser shall be repaired as directed by the engineer, by and at the expense of the laying contractor.

Sec. 4.3—Welded Field Joints—Coal-Tar Enamel Lining and Coating

4.3.1. The coal-tar primer and coal-tar enamel used shall be the same material as used for coating and lining pipe.

4.3.2. *Interior.* Before field pressure testing, interior welds of field joints shall be cleaned. Primer shall then be applied and allowed to dry according to the coating manufacturer's instructions. Hot enamel shall next be applied with daubers to specified thickness and shall overlap the main body of coating on each side of the weld to form a continuous coating free from defects. For coating field joints, there shall be located at frequent intervals along the pipe pour holes through which hot enamel may be poured into enameling buckets inside the pipe. (The require-

ments of this paragraph are applicable only to those sizes of pipe—27 in. and larger—into which it is possible to enter for cleaning and applying primer and enamel.)

4.3.3. *Exterior.* After field pressure tests have been completed, joints shall be cleaned and primed. When the primer is dry, the field joints shall be manually coated to the specified thickness. Enamel shall overlap the coating on each side of the field joint to form a continuous external coating free from defects.

4.3.4. All hand enameling shall be done in accordance with the procedure outlined in paragraphs under Sec. 3.11 of these specifications, and heating of enamel for field application shall be done in accordance with the procedure outlined in paragraphs under Sec. 3.5 of these specifications.

4.3.5. All field coating work shall be thoroughly inspected by the contractor using an electrical flaw detector, and any flaws or holidays found shall be repaired by the contractor.

Sec. 4.4—Mechanical Couplings—Cleaning, Priming, and Coating

At the point of manufacture, all couplings shall be cleaned, then primed with the coal-tar primer specified by the manufacturer of the coating used on the pipe. The couplings and the exposed pipe ends shall be reprimed in the field. When the primer is dry, these surfaces shall be coated with the AWWA coal-tar enamel coating recommended by the manufacturer of the coating used on the pipe. The coating shall be capable of conforming to the normal movement of the buried pipe without cracking.

Sec. 4.5—Backfilling

Backfilling shall be conducted at all times in such a manner as to prevent damage and abrasion to coal-tar enamel exterior protection on pipe.

4.5.1. Placing of backfill about exterior-protected pipe shall be done only in the presence of the inspector after his final inspection and acceptance of exterior protection on the pipe.

4.5.2. Immediately after placing and aligning pipe in the trench and before completing the joint, loose backfill shall be placed about the pipe to a depth of about 6 in. above the pipe, except at field joints. This backfill shall consist only of fine soil, sand, or other selected backfill.

4.5.3. If rocks or other hard objects occur in the backfill along any section of the pipeline, such backfill shall be screened before being placed about the pipe, or, at the option of the contractor, suitable waste backfill from other parts of the line may be transported to and placed about the pipe in such sections.

4.5.4. Settlement of backfill in the trench shall be by means of flooding, puddling, tamping, or jetting. Rodding with metal rods will not be permitted.

Section 5—Application of Paint to Exposed Exterior Steel Surfaces Erected Aboveground

Sec. 5.1—General

Contractor shall furnish all labor, equipment, and materials required and shall prepare, paint, or coat all exposed steel surfaces erected aboveground.

5.1.1. For ordinary atmospheric conditions, the steel surfaces shall receive two coats of synthetic red lead primer (or one coat of synthetic red lead primer and one coat of synthetic white enamel) and one coat of aluminum paint.

5.1.2. For more corrosive than normal conditions, the steel surfaces shall receive one coat of heavy-bodied, cold-applied coal-tar coating, one coat of heavy-bodied coal-tar emulsion, and one coat of aluminum paint. This system may be applied either to bare metal or to plates and structurals which have been properly cleaned at the shop, then shop primed with one coat of coal-tar primer referred to in Sec. 2.1. Each coat of coal-tar coating and coal-tar emulsion shall be applied at the coverage rate of approximately 60 sq ft per gallon.

Sec. 5.2—Preparation of Exterior Surfaces of Pipe

Preparation of exterior surfaces shall comply in all respects with the procedure outlined in paragraphs under Sec. 3.2 of these specifications. After completion of field-welded joints, they shall be properly cleaned before field application of red lead primer or the cold-applied coal-tar coating.

Sec. 5.3—Priming of Exterior Surfaces of Pipe

5.3.1. Red lead primer to be used shall be as specified in paragraphs under Sec. 2.6 of these specifications. Application of red lead primer shall be as specified for coal-tar priming in Sec. 3.3.1–3.3.4, inclusive, of these specifications.

5.3.2. Coal-tar primer shall be applied to all shop-blasted surfaces which are to be coated in the field with cold-applied coal-tar coating and coal-tar emulsion. Coal-tar primer to be used shall be as specified in paragraphs under Sec. 2.1 of these specifications. Application of coal-tar primer shall be as specified in paragraphs under Sec. 3.3 of these specifications. The coal-tar primer shall not be applied to surfaces which are to be blasted in the field after erection.

5.3.3. Care shall be taken to prevent abrasion or scarring of the primed surfaces before the film has dried hard and firm. Any damage to red lead or coal-tar primer shall be repaired before subsequent coats are applied. Red lead primer shall be allowed at least 24 hr drying time before a second coat of red lead primer or white enamel is applied.

Sec. 5.4—Second Coating of Exterior Surfaces of Pipe

Material and application for the second coat of red lead primer or white enamel shall comply in all respects with these specifications.

Sec. 5.5—Finish Coat of Aluminum Paint on Exterior Steel Surfaces

5.5.1. Finish coat shall be aluminum paint applied in the field by air spray gun in one or two coats as specified by the purchaser.

5.5.2. Aluminum paint shall be composed of aluminum vehicle and aluminum bronzing pigment in accordance with these specifications. Aluminum

paint shall be mixed in the field as required for the work in a ratio of 2 lb of pigment to 1 gal of vehicle. No additional thinner shall be used in the paint.

5.5.3. Before application of finish coat of aluminum paint, the field joints shall be cleaned of all dirt and rust and primed and recoated with the same material in the same manner as prescribed for shop priming of the pipe.

Sec. 5.6—First Coat of Cold-applied Coal-Tar Coating

5.6.1. Cold-applied coal-tar coating to be used shall be as specified in paragraphs under Sec. 2.10 of these specifications. This cold-applied coal-tar coating shall not be applied to the inside surfaces of the pipe because it may impart a taste to potable water. It can be applied by brushing or spraying. Special equipment is required for satisfactory spray application. It shall be applied at the coverage rate of approximately 60 sq ft per gallon. This cold-applied coal-tar coating must be applied either to bare metal or to plates and structurals which have been properly cleaned at the shop, then shop primed with one coat of coal-tar primer referred to in Sec. 2.1. This coating shall not be applied to surfaces previously painted with red lead primer. The surfaces shall be dry at the time the coal-tar coating is applied, and no coating shall be applied during rain or fog.

5.6.2. The cold-applied coal-tar coating applied in the field shall be allowed at least 24 hr drying time before the coat of coal-tar emulsion is applied.

Sec. 5.7—Application of Cold-applied Coal-Tar Emulsion

5.7.1. Cold-applied coal-tar emulsion to be used shall be as specified in paragraphs under Sec. 2.11 of these specifications. This emulsion shall not be applied to the interior surfaces of the pipe. It may be applied by brushing or spraying. Special equipment is required for satisfactory spray application. It shall be applied at the rate of approximately 60 sq ft per gallon. This cold-applied coal-tar emulsion shall be applied over the cold-applied coal-tar coating, after that coat has become dry. No emulsion shall be applied during rain or fog.

5.7.2. Containers of the cold-applied coal-tar emulsion shall be kept at temperatures above 32°F to prevent freezing.

APPENDIX

Section A1—General

Sec. A1.1—Scope

This Appendix covers material specifications and application procedures for additional exterior protection required as follows:

A1.1.1. *For the outside of all pipe less than 30 in. in diameter to be placed underground,* a coat of coal-tar primer followed by a hot coat of coal-tar enamel into which shall be bonded a single layer of asbestos felt wrap, and finished with one coat of water-resistant whitewash or a single wrap of kraft paper, as outlined in Sec. A1.2.

A1.1.2. *For the outside of all pipe, regardless of diameter, to be placed underground,* under unusual construction conditions, a coat and wrap system best suited to the conditions outlined in one of the sections A1.2, A1.3, A1.4, or A1.5 in this Appendix.

A.1.1.3. These additional exterior protective measures, for pipe to be installed under unusual construction con-

ditions, are not a part of the specifications unless specifically included by the purchaser as provided in Sec. 1.3 of the main specifications.

Sec. A1.2—Bonded Asbestos Felt Wrap

A1.2.1. This type of additional exterior protection shall be used on all pipe less than 30 in. in diameter to be placed underground; or when the engineer desires a single wrap on pipe 30 in. in diameter and larger to provide additional exterior protection because of soil stresses.

A1.2.2. The pipe shall be lined on the inside and coated on the outside with coal-tar enamel in accordance with all provisions of the specifications, and the enamel used on the outside shall be applied to a thickness of $\frac{3}{32}$ in. with an allowable variation of $\pm \frac{1}{32}$ in. under the asbestos felt.

A1.2.3. Asbestos felt shall conform to the material specified in Sec. A2.1 of this Appendix.

A1.2.4. Application of the asbestos felt shall conform to the procedure specified in Sec. A3.1 of this Appendix.

A1.2.5. Final pipe protection shall be whitewashed as provided in the specifications or wrapped with kraft paper specified in Sec. A2.2 of this Appendix.

Sec. A1.3—Coal-Tar Enamel and Bonded Double Asbestos Felt Wraps

A1.3.1. This type of additional exterior protection shall be used only where extraordinarily severe soil conditions exist, or on submarine lines, river crossings, etc.

A1.3.2. The pipe shall be lined on the inside and coated on the outside with coal-tar enamel in accordance with all provisions of the specifications, and the enamel used on the outside shall be applied to a thickness of $\frac{3}{32}$ in. with an allowable variation of $\pm \frac{1}{32}$ in. under the first bonded wrap of asbestos felt, and $\frac{1}{32}$-in. minimum thickness under the second bonded wrap of asbestos felt.

A1.3.3. Asbestos felt shall conform to the material specified in Sec. A2.1 of this Appendix.

A1.3.4. Application of the asbestos felt shall conform to the procedure specified in Sec. A3.1 of this Appendix.

A1.3.5. Final pipe protection shall be whitewashed as provided in the specifications or wrapped with kraft paper specified in Sec. A2.2 of this Appendix.

A1.3.6. The resultant construction of this exterior protection shall be:

(1) Coal-tar primer.

(2) Coal-tar enamel ($\frac{3}{32}$ in., $\pm \frac{1}{32}$ in., thick).

(3) Bonded asbestos felt.

(4) Coal-tar enamel ($\frac{1}{32}$ in. minimum).

(5) Bonded asbestos felt.

(6) Whitewash (or kraft paper).

Sec. A1.4—Coal-Tar Enamel, Fibrous Glass Mat, and Bonded Asbestos Felt Wrap

A1.4.1. This type of additional exterior protection shall be used only where extraordinary soil conditions exist, or on submarine lines, river crossings, etc.

A1.4.2. The pipe shall be lined on the inside and coated on the outside with coal-tar enamel in accordance with all provisions of the specifications, except that the fibrous glass mat shall be embedded in the outside of the enamel applied to a thickness of $\frac{3}{32}$ in. with an allowable variation of $\pm \frac{1}{32}$ in.; and there shall be a $\frac{1}{32}$-in. minimum thickness of enamel under the bonded wrap of asbestos felt.

A1.4.3. Fibrous glass mat shall conform to the material specified in Sec. A2.3 of this Appendix.

A1.4.4. Asbestos felt shall conform to the material specified in Sec. A2.1 of this Appendix.

A1.4.5 Application of fibrous glass mat shall conform to the procedures specified in Sec. A3.2 of this Appendix.

A1.4.6. Application of the asbestos felt shall conform to the procedures specified in Sec. A3.1 of this Appendix.

A1.4.7. Final pipe protection shall be whitewashed as provided in the specifications or wrapped with kraft paper specified in Sec. A.2.2 of this Appendix.

A1.4.8. The resultant construction of this exterior protection shall be:

(1) Coal-tar primer.

(2) Coal-tar enamel ($\frac{3}{32}$ in., $\pm \frac{1}{32}$ in., thick).

(3) Fibrous glass mat.

(4) Coal-tar enamel ($\frac{1}{32}$ in. minimum).

(5) Bonded asbestos felt.

(6) Whitewash (or kraft paper).

Sec. A1.5—Sand Shield

A1.5.1. This type of exterior protection shall be used only when the methods of backfill as required in Sec. 4.5 of the specifications are not available or are considered undesirable.

A1.5.2. The pipe shall be lined inside and coated outside with coal-tar enamel in accordance with all provisions of the specifications. In addition, the entire pipeline, or such portions of the line as are designated by the purchaser, shall be completely surrounded by sand before any backfill is placed in the trench. A minimum depth of 3 in. of sand shall be placed in the trench before the pipe is laid, and the sand shall be placed about the pipe and to a minimum cover of 3 in. over the pipe.

Sec. A1.6—Reinforced Cement-Mortar Shield

When a reinforced cement-mortar shield is desired over the exterior coat of coal-tar enamel, the materials and application procedures shall conform to the applicable requirements of AWWA Specifications C205.

Section A2—Material Specifications

Sec. A2.1—Asbestos Coal-Tar Saturated Felt

The wrapper shall be composed of an asbestos felt having an asbestos content of not less than 85 per cent of the desaturated felt with suitable binder, the whole saturated with a distilled coal-tar to produce the following characteristics in the finished felt:

A2.1.1. *Appearance.* The finished tar-saturated asbestos felt shall have a calendered surface free from visible external defects. When unrolled at temperatures of 32°–100°F, it shall not stick to such an extent as to cause tearing.

A2.1.2. *Weight per 100 sq ft.* Exclusive of all conmminuted surfacing or sand which has been added to prevent sticking in the rolls, the weight shall be not less than 12 lb nor more than 15 lb per 100 sq ft.

Test method. ASTM D146–47, Sec. 1–9.

A2.1.3. *Breaking strength.* Average after test samples from the inside of the roll have been aged in free air for 72 hr:

(1) With fiber grain (longitudinal), not less than 25 lb.

(2) Across fiber grain (transverse), not less than 10 lb.

Test method. ASTM D146–47, Sec. 12(a).

A2.1.4. *Pliability.* Average after test samples from the inside of the roll have been aged in free air for 72 hr: No cracking of felt when bent over a 1-in. mandrel at 77°F.

Test method. With the trimmer described in Sec. 12(a) of ASTM D146–47, five 6-in. strips shall be cut with the fiber grain as shown at D-1 to D-5 (Fig. 1 of the ASTM specification) and immersed in water at 77°F (25°C) for 10–15 min. These strips shall be bent through 180 deg at a uniform speed, in exactly 2 sec, around a mandrel with a diameter of 1 in.

A2.1.5. *Saturation.* Average after test samples from the inside of the roll have been aged in free air for 72 hr: The saturation by extraction shall be not less than 22 per cent nor more than 32 per cent of the weight of the extracted felt.

Test method. ASTM D146–47, Sec. 16, omitting correction for entrained carbonaceous materials, calculated as follows:

$$\frac{\text{wt. of extracted saturant} \times 100}{\text{wt. of extracted felt (as defined)}} = \%\ \text{saturation}$$

A2.1.6. *Loss on heating.* The loss on heating shall be not more than 10 per cent according to the following test method:

Test method. Cut two samples, 6 in. wide by 12 in. long, of saturated felt, weighing each strip, and suspend by wire hooks for 2 hr in an oven maintained at 200°F, ± 5°F. Care shall be taken to see that the felt does not touch the oven side or other samples of felt and that localized overheating of the samples does not take place. Remove from the oven, cool in a desiccator, and weigh. Compute the percentage of loss in weight based upon the original weight of the sample, minus the weight of surfacing. The average of the result on the two samples shall be reported as the loss on heating.

Sec. A2.2—Kraft Paper

The kraft paper shall be an 80-lb, 100 per cent sulfate, smooth. It may be imprinted at intervals with the name of the applicator or steel pipe manufacturer.

Sec. A2.3—Fibrous Glass Mat

A2.3.1. The fibrous glass mat shall be a thin, flexible, uniform mat, composed of glass fibers in an open porous structure, bonded together with a thermosetting resin which shall be compatible with the hot coal-tar enamel.

A2.3.2. No disbonding of individual glass fibers during or following the embedding process shall occur.

A2.3.3. The fibrous glass mat shall not cause bubbling under the conditions of application.

A2.3.4. The mat shall be sufficiently porous so that it can be embedded in the hot coal-tar enamel as it is applied to the exterior of the pipe.

A2.3.5. The mat shall be approximately 18 mils in thickness.

Section A3—Application Procedure

Sec. A3.1—Application of Asbestos Coal-Tar Saturated Felt

Asbestos felt shall be mechanically applied in a continuous end-feed machine or in a lathe-type machine or by approved field felt application equipment.

A3.1.1. External enamel and asbestos felt wrapper shall be applied to the revolving pipe so as to produce a coal-tar enamel coating to a thickness of $\frac{3}{32}$ in., and the allowable variation in the enamel thickness shall not exceed $\pm \frac{1}{32}$ in. The asbestos felt shall be definitely and positively bonded to the enamel. The enamel coating shall be continuous and free from defects, skips, or holidays.

A3.1.2. The asbestos felt as specified in Sec. A2.1 shall be of suitable width for smooth, spiral application and shall be of approximately uniform width. The lap of the felt shall be not less than $\frac{1}{2}$ in. The asbestos felt shall be applied neatly and smoothly and shall be free of wrinkles and buckles.

A3.1.3. Over the bonded asbestos felt wrapper shall be applied a spiral wrapping of kraft paper as specified in Sec. A2.2, unless outside surfaces are to be coated with whitewash following final inspection as specified in Sec. 3.14 of the main specification.

Sec. A3.2—Application of Fibrous Glass Mat

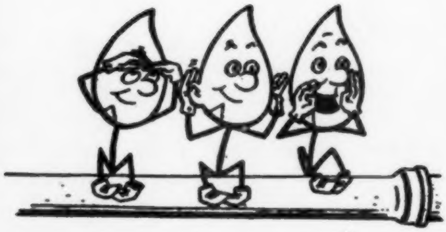
Fibrous glass mat shall be mechanically applied in a continuous end-feed machine or in a lathe-type machine or by approved felt application equipment.

A3.2.1. The fibrous glass mat shall be applied simultaneously with the first coat of coal-tar enamel. Sufficient tension shall be applied to the roll of fibrous glass mat to embed it in the enamel before the enamel sets or cools. The fibrous glass mat shall not be pulled through the hot enamel to the metal surface.

A3.2.2. The fibrous glass mat as specified in Sec. A2.3 shall be of suitable width for smooth, spiral application and shall be of approximately uniform width. The lap of the fibrous glass mat shall not be less than $\frac{1}{2}$ in.

A3.2.3. The second coat of hot coal-tar enamel shall be applied over the fibrous glass mat simultaneously with a single bonded wrap of asbestos coal-tar saturated felt.

A3.2.4. Fibrous glass mat shall not be used when two wraps of asbestos coal-tar saturated felt are applied in accordance with Sec. A1.3 of this Appendix.



Percolation and Runoff

Solace, like tranquility, is now purchasable. Unlike the tranquilizers, however, the consolers are not pills but policies and, unfortunately, they offer not general relief, but specific solace. At the moment, however, we can think of no solace more in demand than that for a vacation spoiled by rain, and it is for that calamity that the Fireman's Fund Insurance Group offers insurance that will pay claims of up to $1,200 "to soothe your disappointment and help restore vacation funds." Without getting into the fine-print details, we can report that the premium charged is 5 per cent of the principal and that the payoff is based not only on the principal, but on the number of days of rain, with the minimum payment 10 per cent of the principal if approximately half the days are rainy. As analyzed by *Fortune* magazine, for a September vacation in San Francisco—one of the 88 vacation areas covered—the odds against 5 days of rain in a 2-week vacation period are about 500 to 1, whereas the payoff for that number of days would be only 2 to 1. Still, if it's solace you want, the price is bound to be high—and to the water works man any payment at all would be the best price he ever got for water.

Were this only a matter of fun on vacation, though, we would never have mentioned it, for the water works man, we understand, rarely has time for a vacation and, when he does, we've been told, he spends it visiting other water works. What we should like to suggest, though, is the possibility of a reciprocal policy for the nonvacationing water works man—that is, drought insurance. If we know insurance people at all, we are certain they will be anxious to hedge their vacation coverage against a rainy day, and what better way than by offering the water works man a little solace during drought. As a matter of fact, had insurance like this been available, Texas' 7-year drought might well have paid for the facilities necessary to combat it. And right now in a good part of the Northeast, policy writer's cramp would be epidemic.

For a happy or prosperous vacation, if not for a full or fund-raising reservoir, see your solace broker now!

Conway B. Briscoe has been named water commissioner at St. Louis, succeeding Thomas J. Skinker, who retired Jan. 15 (see March 1957 P&R, p. 80). Mr. Briscoe has been director of public utilities at St. Louis since 1949.

(*Continued on page 36 P&R*)

(Continued from page 35 P&R)

Not hollers, but dollars was the response of customers at Frontenac, Kan., last month when their water supply was shut off to permit repairing the storage tank. And water superintendent John Cornella, who had fully expected a march of homeowners on city hall, wasn't at all prepared to have them stop at the bill collection counter. Finding it hard to believe that Frontenacian consciences are any more guilty than those in other communities, we wonder if we haven't stumbled upon a new and much more subtle technique for collecting overdue accounts. At any rate, we have a fair idea of when a most happy Cornella will do his repair work from now on. And well may it be dun!

Predun bills are getting their share of attention, too. First, toward making them less painful, banks and utilities have been working on a new plan of "preauthorized checks," whereby the utility customer authorizes the utility to draw a check against his bank account to pay his bill and then authorizes the bank to honor the check without his signature. On the other hand, toward making them less painless, the Galena Park, Tex., city council just voted to add 50 cents to the June, July, and August water bills to pay the cost of spraying the city to control mosquitoes. Neither the painlessness nor the painlesslessness is likely to make life significantly simpler for the water works man.

Of course, with the water supply so often taken for granted, it may be only logical for the water works man, too, to take for granted—from the customer's bank account—the money required to pay for the water supplied, but we have an idea that this kind of reaching into the customer's pocket and helping oneself may be fraught with more hazards to public relations than its values in reduced collection costs will be worth. Furthermore, with the industry as a whole working hard to eliminate take-for-grantedness, it hardly seems logical to dispose of one of the water utility's very few points of contact with its customers. It may be true, of course, that no contact at all is better than the kind that may produce friction, but then, certainly, we ought to get hold of something more foolproof than the customer's bank account—his paycheck at least. It would, after all, be simple enough to have his employer, who is already paying most of his income tax for him and probably helping him to buy government bonds, authorized to withhold the funds necessary to pay his water bill and, for that matter, any other—but that's another matter.

And still another matter ought to be the business of mosquito control—unless, of course, the tie-in at Galena Park is some similarly subtle type of bill-collecting scheme as Frontenac's repair work. Although the new and used water argument has led us to accept the idea of making room for the sewer service charge on the water bill, we have been unable to rationalize the joint administration of water and mosquito control accounts even as successfully as, for instance, water and television repair accounts, which can, at least, be billed as water, women, and song.

Neither preauthorized nor preoccupied, the water bill shouldn't be too hard to take straight. And if collect as collect can doesn't work, with the right kind of imagination, to dun can be fun.

(Continued on page 38 P&R)

(*Continued from page 36 P&R*)

Clothes to burn is what every woman wants, and it won't be long now until every man will be able to give her just that. It is Kimberly-Clark Corp.'s researchers who are the benefactors involved, having come up with the formula for one-time throw-away paper clothing. Not yet among the fashions offered by Paris couturiers, paper costumes are as yet being aimed principally at the field of hard-to-wash utility garments, such as industrial coveralls, policemen's ponchos, aprons, and hospital gowns. But they are such a natural for women's dresses, in which no self-respecting female ever wants to be seen more than once anyway, that it shouldn't be too long before our beloveds appear in newspaper prints or onionskin organdy.

Actually, it isn't only the personal side of paper clothing that should be of interest to us—particularly until we know how much a tissue evening gown is going to cost—but the evaluation of the effect of paper clothing on water use. Carried far enough, the shift to paper could certainly make a significant change in water demand as the eraser and the match replaced the washing machine. Still with paper manufacturing one of the largest consumers of water, the overall change would probably be upward—particularly in view of the increase in fire protection water that will undoubtedly be required.

And speaking of water, the paper bathing suit will, if nothing else, add considerable interest to that "wet-strength" commercial.

Mathew M. Braidech, research director, National Board of Fire Underwriters, New York, has been awarded the Benjamin G. Lamme Medal by Ohio State University. The medal is presented annually to an alumnus for "meritorious achievement in engineering or the technical arts."

Lock Joint Pipe Co., East Orange, N.J., has announced the election of Hugh F. Kennison as vice-president in charge of engineering and research. R. J. Sweitzer has been named director of research and development.

A lost weekend at Lillington, N.C., last month meant just about what that term is intended to imply—that is, almost every Lillingtonian was off the water wagon at once. The occasion, however, wasn't Bacchus' birthday or even the grand opening of the Lillington Liquor Store. As a matter of fact, not only were things not convivial, but the town was practically deserted. And "deserted" is the word, for the water department was taking the occasion of a changeover from a deep well supply to a filtered surface supply to interrupt service and give the whole distribution system a thorough flushing and redisinfection. The cleaning and changeover process meant that there would be no potable water between 8 AM Saturday and 12:30 AM Monday—a weekend lost to all but a few temperate souls who didn't object to pouring their water out of bottles and were willing to spend the week before stocking their cellars. Of course, it wasn't exactly "lost" to the water department either, for the job of getting the stage set for the unveiling of a new supply upon which 1,100 Lillingtonians had spent $100,000 must have made those 40½ hr busy ones. After all, it wouldn't do to have the lost weekenders seeing things in their cups—even if they weren't as spectacular as purple dragons or pink elephants.

(*Continued on page 40 P&R*)

(Continued from page 38 P&R)

Not dragons and elephants, but almost every other kind of beast seems in the past few months to have plagued water works men somewhere:

Thus, at Trenton, N.J., it was a frog in the throat—well, on its way to the throat—that perturbed the water department. The throat belonged to a Mrs. Carl Burkard, who claimed that the frog—a Hylacruisifer, no less—plopped out of her faucet when she drew a drink of water. Not at all timid, Mrs. Burkard "captured" the beast and imprisoned it, first, in a bottle and, then, in an aquarium where it now plays with a pet salamander to prove her point.

Not much later at Doberdo, Italy, the water superintendent and the whole community were considerably more perturbed when the town's reservoir completely dried up for no apparent reason. What was unapparent was a big trout that had managed to disrupt the electrical pumping system and thereby cut off the supply.

Then at Milwaukee, of all places, it was two hippopotam . . . well, one hippopotamus and another hippopotamus at the Washington Park zoo that stood in the way of water works progress, forcing cancellation of plans to recharge a deep well. The well, it seems, provides the water in which the two . . . in which Tony and Cleo "cavort." Recharging it would have involved shutting it down, which would have meant that the . . . that Tony and Cleo would have to use water from the regular city supply—much too cold for their delicate hippopotamic constitutions.

Back overseas at Raccuja, Sicily, still another village supply was reduced to a trickle recently even though there was plenty where it came from. There it took a number of inspectors some time to find and remove a 7-ft snake from the aqueduct, disinfect the line, and restore it to service.

And at Yarmouth, Nova Scotia, just 2 months ago, the same result on a smaller scale was accomplished by a 3-in. fish lodged in a service pipe.

What with hydrantphilic, meter-readerphobic dogs, with catcalling meters and faucets, with goldfish allergic to the chlorine in water supplies, and with seagulls, ducks, and sundry other winged nuisances hovering over his reservoirs, the water works man must often feel like fair game for any beast—and especially the purple dragon and the pink elephant.

Manganetism attracts only irony! Thus, if your supply is manganetic, you'll do well to pass the word along to AWWA Task Group 2680 P, which is specifically charged with helping you rid yourself of this reason for customer irony, if not irateness.

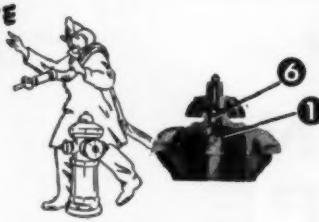
Lest you be poor at numbers, we should perhaps point out that the group's task is entitled "Manganese Deposition in Pipelines" and that its answer to the problem cannot be found until the extent and nature of the problem is fully known. In that, only the manganetized can help, so if you have a manganese problem, let committee chairman A. E. Griffin, Box 178, Newark, N.J., know all about it. He'll pass the word along to the committee member handling that aspect of the problem, and one of these days the manganetic field won't be ours.

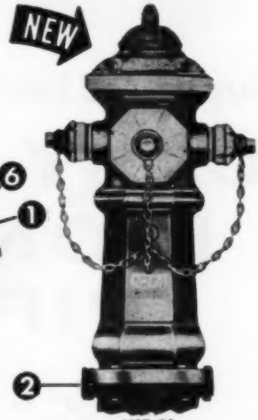
M. R. Norsworthy, general manager of the Albertville, Ala., Municipal Utilities Board, has accepted the position of water superintendent at Auburn, Ala.

(Continued on page 42 P&R)

A. W. W. A. HYDRANTS

EASY TO OPERATE AND MAINTAIN





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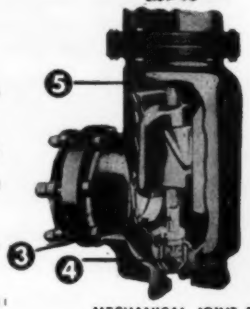

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(LUDLOW) (RENSSELAER) **VALVES & HYDRANTS**

Since 1861 THE LUDLOW VALVE MANUFACTURING CO. Troy, N. Y.

(Continued from page 40 P&R)

One of the most ambitious engineering pipe fabrication and installation projects to be undertaken in Southern California in recent years is now under way on the Metropolitan Water District's Colorado River Aqueduct. A total of 47 inverted siphons to be placed along a 183-mile segment of the aqueduct will help bring the gigantic water supply line to its full planned delivery capacity of more than 1 bgd. The aqueduct is now delivering approximately half that amount.

The precast reinforced concrete siphons vary in length from 73 ft to 15,400 ft, with inside diameters up to 13½ ft. The 16-ft pipe sections will weigh 62–68 tons each. Fabrication and installation are being performed by American Pipe & Construction Co. under two contracts totaling nearly $16,000,000. Because of the size of the pipe and the distances involved, the company is erecting a semiportable field plant which will be moved to a second location as the work progresses. Completion of the project, which is part of the Metropolitan Water Dist. $200,000,000 expansion program under the direction of General Manager & Chief Engineer Robert B. Diemer, is expected by the end of 1958.

What Price Water? has suddenly become more than an idle question down in the Republic of Panama, where a Minister of Health, Welfare, and Labor who can safely be called pretty feels that the water supplied to the republic by the Panama Canal Co. from its Miraflores filtration plant is no bargain at all at 8.9 cents per 1,000 gal. Thus, on her recent visit here, Senora Minister Cecilia Pinel de Remon indicated her intention to recommend building a dam, filtration plants,

(Continued on page 44 P&R)

(*Continued from page 42 P&R*)

and the necessary aqueducts to bring in a republican supply at only 5 or 6 cents per 1,000 gal. For 2 cents, in other words—or not much more than that—republican water, free enterprise, competition. What—Price War?

Ideography, the process by which the Japanese communicate with each other in writing, gives us an idea of why our Oriental friends seem sometimes to talk so much to say so little. At any rate, we have to admit to being disappointed when a book ideographed as "Laws for Modifying Spirits of the Sky" turned out to be strictly a technical manual, and then not even as romantic a one as Dr. Krick's formula for cloud seeding, but a translation of a Trane Co. publication entitled *Air Conditioning*. Disillusioned or not, though, we're wishing right now that some of those "Laws" could be passed, although it is doubtful if even the spirits of the sky could overcome New York City heat and humidity. Right now with both of them pushing 100, certainly there ought to be a law!

Chemists and microbiologists engaged in water analysis and treatment may be interested in the activities and publications of the Society for Water Treatment and Examination, a British organization whose more than 200 members come from all over the world. Membership in the society is open to chemists and microbiologists over 21 years of age who have had at least 3 years' experience in the field. Papers presented at meetings held twice a year

(*Continued on page 46 P&R*)

(*Continued from page 44 P&R*)

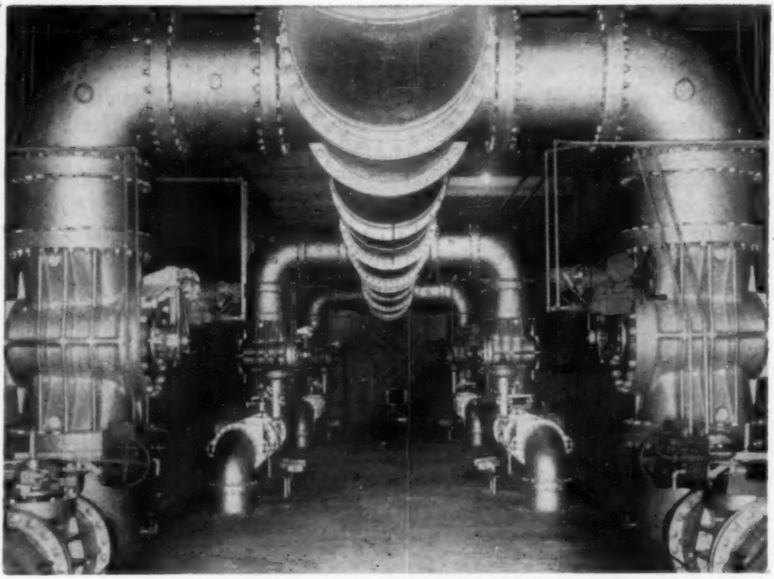
in England are published, with discussions and authors' replies, in semiannual *Proceedings* available to nonmembers at 10s 6d per copy. Inquiries should be addressed to: A. W. H. McCanlis, 41 Carshalton Rd., Sutton, Surrey, England.

Louis R. Howson, senior partner of the consulting firm of Alvord, Burdick & Howson, Chicago, has been nominated for president of ASCE and will take office this fall. Long prominent in AWWA affairs, he was president in 1942 and is, of course, currently chairman of the AWWA Committee on Water Works Practice, a post he has ably filled since 1947.

Two other professional-society appointments also made news last month. American Welding Society has named Fred L. Plummer national secretary, succeeding Joseph G. Magrath, who resigned. Director of engineering for Hammond Iron Works, Warren, Pa., since 1940, Mr. Plummer served two terms as AWS president, holding office from 1952 through 1954. Oscar B. Schier II, deputy secretary of ASME, has been designated secretary-elect of that organization, to replace the retiring Clarence E. Davies. Mr. Schier has been an ASME staff member since 1946.

"All the Water You Need, When and Where You Need It!" is appar-

(*Continued on page 48 P&R*)



(*Continued from page 46 P&R*)

ently not getting the kind of reception we could hope for in Sverdlovsk, USSR—at any rate not so far as hot water on Saturday night in Sverdlovsk bathtubs is concerned. There Soviet authorities and Sverdlovskian bathers are engaged in a cold war over the amount of hot water to which a comrade is entitled in his weekly tub. Cause of this red water trouble, apparently, is the inability of the Urals Machine Works, purveyors of the hot water, to supply the demand. And cure has been to insert washers that restrict the flow, thus, communistically, to share the shortage rather than overcome it. Some Party poopers are apparently defiant to the point of letting the hot water trickle until the tub is full, but even they have to admit that things aren't so hot right now—in fact, they say, they may soon stink. Of course, there, "all the hot water you need" isn't just a matter of Btu's and pipelines, but of OGPU's and party lines as well. So—"All the Water You Deserve, Next Five-Year Plan in Siberia!"

Connecticut has established a new State Water Resources Commission, consisting of seven members representing various economic and other groups particularly concerned with water resources. The commission will take over the duties of three former state agencies—the State Water Commission (pollution control), the State Flood Control & Water Policy Commission, and the State Board of Supervision of Dams, Dikes, and Reservoirs. Director of the new commission is William S. Wise, formerly head of the State Water Commission. Warren J. Scott will represent the State Dept. of Health.

Sanity engineering was what Caltech's Jack McKee was credited with professing by the Tustin, Calif., *News* last month in what must be classified as one of those Freudian slips, for sense is exactly what Jack was professing to the Tustin Lions Club in the reported after-luncheon talk. Plugging for a revision of state health rulings on reuse of water as a means of augmenting available supplies, Jack cited such examples as the much reused Ohio River, ten times the normal flow of which is used for water supply. We don't know if he mentioned Chanute, Kan. (January P&R, p. 35), or whether he pointed out that even the water Californians use has been used before, if more remotely, but sanity is what Jack was a professor of—which, of course, entitles him to teach at a menial health institution.

Eric W. Denholm, engineer of the Stirlingshire & Falkirk Water Board, Scotland, has been awarded the "President's Premium" by the Institution of Water Engineers (Great Britain) for his paper on automatic operation at the Broadside Filter Plant, presented at a 1956 meeting of the Institution's Scottish Section. Mr. Denholm's paper was published in the June 1956 issue of JOURNAL AWWA, and also appeared in the February 1957 number of the *Journal of the Institution of Water Engineers.*

Robert R. Porter is the new president of Keasbey & Mattison Co., Ambler, Pa. Executive vice-president since March 1956, he succeeds Ernest Muehleck, who has retired.

John D. Wedeman, formerly chief, Water & Sewage Branch, Headquarters 4th US Army, Fort Sam Houston, Tex., has been promoted to assistant chief of the Water & Sanitation Branch, Office of Chief of Engineers, Washington, D.C.

Service Lines

Plastic pipe installation, application, and specifications are covered in a catalog of Orangeburg SP Plastic Pipe, made from a recently developed polyethylene resin. Copies of Catalog 401 are available from Orangeburg Mfg. Co., Orangeburg, N.Y.

Relief and back-pressure valves for handling corrosive liquids are described in Bul. 357 (4 pages) issued by Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

An automatic valveless filter which can be used wherever gravity flow is feasible, and which is said to eliminate or minimize instrumentation, manpower, and maintenance costs, is the subject of an 8-page bulletin obtainable from The Permutit Co., 330 W. 42nd St., New York 36, N.Y.

Dorr-Oliver pumps for chemical processing are illustrated and described in a 20-page general bulletin, "Application Engineering," available from the company at Barry Place, Stamford, Conn.

Measuring and control equipment made by Simplex is described in detail in an illustrated 36-page catalog, Bul. 005, issued by Simplex Valve & Meter Co., Lancaster, Pa.

Chemicals produced by Reilly Tar & Chemical Corp. are listed and described briefly in the "Reilly Chemical Index," an 8-page catalog available from the company at Merchants Bank Bldg., Indianapolis 4, Ind.

(Continued on page 52 P&R)

Service Lines

(*Continued from page 50 P&R*)

Carbonation units for plants of 2-mgd capacity or less are described in Bul. 7W88 (6 pages), issued by Walker Process Equipment Inc., Box 266, Aurora, Ill. These package systems, with capacities ranging from 55 to 660 lb of CO_2 per day, operate on methane or propane gas.

'The Road Ahead' is the title of a 24-page booklet giving facts and figures on the superhighway program recently authorized by Congress. Copies may be obtained from Advertising Div., Caterpillar Tractor Co., Peoria, Ill., or from local Caterpillar dealers.

Main disinfection data, including a nomogram simplifying flow and dosage calculations, are given in Keep Sheet 12A, available from Proportioneers, Inc., Div. of B-I-F Industries, 345 Harris Ave., Providence, R.I.

A slide calculator for pipe friction losses is offered by Allis-Chalmers. Requests for the $9\frac{1}{4} \times 4$-in. pocket calculator should be made, on official letterhead, to Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

Steel water pipeline installations are illustrated and described briefly in an 8-page brochure, entitled "Steel Water Pipe . . . Economical to Install, Economical to Maintain," prepared by Steel Plate Fabricators Assn., 79 W. Monroe St., Chicago 3, Ill.

Rockwell meters, regulators, and valves are covered, with specifications and photographs, in a revised, condensed, 28-page catalog (C-5000, Rev. 8) which may be obtained from Meter & Valve Div., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

Professional Services

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

DISINFECTION

Retention of Disinfectant Activity in the Presence of Hard Water. E. Kravitz & R. L. Stedman. Appl. Microbiol., **5**:34 ('57). Representative phenolic and quaternary ammonium disinfectants were added to water of moderate hardness (equiv. to 328 ppm $CaCO_3$), and antibacterial activity detd. on a mixt. of *Micrococcus pyogenes* var. *aureus, Salmonella schottmuelleri,* and *Trichophyton interdigitale.* Antibacterial activities were not significantly affected.—*CA*

A Comparison of the Bactericidal Activity of Ozone and Chlorine against *Escherichia coli* at 1°. R. H. Fetner & R. S. Ingols. J. Gen. Microbiol., **15**:381 ('56). Bactericidal effects of ozone solns. were tested against *Escherichia coli* suspensions at 1°, and lethal concn. was found to be that quant. of ozone necessary to produce detectable residue in suspension; under conditions of expts. this was 0.4–0.5 mg/l. Comparison of bactericidal activity of chlorine under similar conditions emphasized different modes of action of 2 agents.—*PHEA*

The Effect of Water Hardness and Temperature on Water Sterilization by Mixtures of Detergents and Quaternary Ammonium Compounds. C. M. Cousins & L. F. L. Clegg. J. Appl. Bacteriol., **19**:250 ('56). 6 quaternary ammonium compounds (QAC) detergent mixt. and the QACs alone were tested for bactericidal efficiency in hard and distd. water, using *E. coli* as test organism, contact times of 1, 2 and 5 min and temps. of 5, 10 and 17°. Efficiencies of unformulated QACs were dissimilar. With all, 200 ppm in hard water was less efficient than 50 ppm in distd. water. Efficiencies of the QAC detergent mixt. were not related to that of pure QAC, efficiency of QAC being increased by 1 detergent formulation and decreased by another. All materials were least efficient at 5°.—*PHEA*

The Problem of Disinfection of the Vienna Water Supply. F. Dosch. Mitt. Osterr. Sanitatsverw., No. 81 ('55). As both spring water sources of Vienna water supply occasionally contain more than 100 coliform organisms per 100 cc. and have bact. count of more than 1,000 per cc., chlorination in reservoirs, which was begun in 1945, must be continued. Account is given of problems presented by 2 spring supplies. As there is certain regularity in bact. conditions of water, flexible control of chlorination is possible. —*WPA*

The Use of Filters to Produce Sterile Water. C. J. McCaffrey & M. I. Cornish. Med. J. Australia, **1**:828 ('56). Method of Seitz filtration has been adopted for producing sterile water for use in operating theatre at Royal Newcastle Hospital, Newcastle, New South Wales. Industrial filter unit was modified for purpose and bact. grade (D 9) filter pads used exclusively. Filter press may be operated with 2, or any multiple of 2, pads. Local water supply had suspended solid content of 7 ppm, but with pressure of 30 psi and 4 pads, convenient flow of 1 gpm was obtained. Local water supply contained 10–89 organisms per ml, and it was estimated that there was wide margin of safety between actual number of organisms to be removed and theoretical filtering capac. of filter. Examn. of samples taken after 6, 12, 24 and 48 hr. continuous running of filter showed them to be sterile. In practice filter is changed every 24 hr. Filter method has following advantages: [1] flexibility—simple to install, at low cost, to any water point, either hot or cold; [2] it is cheaper than steam condensate method; [3] it ensures sterile water.—*BH*

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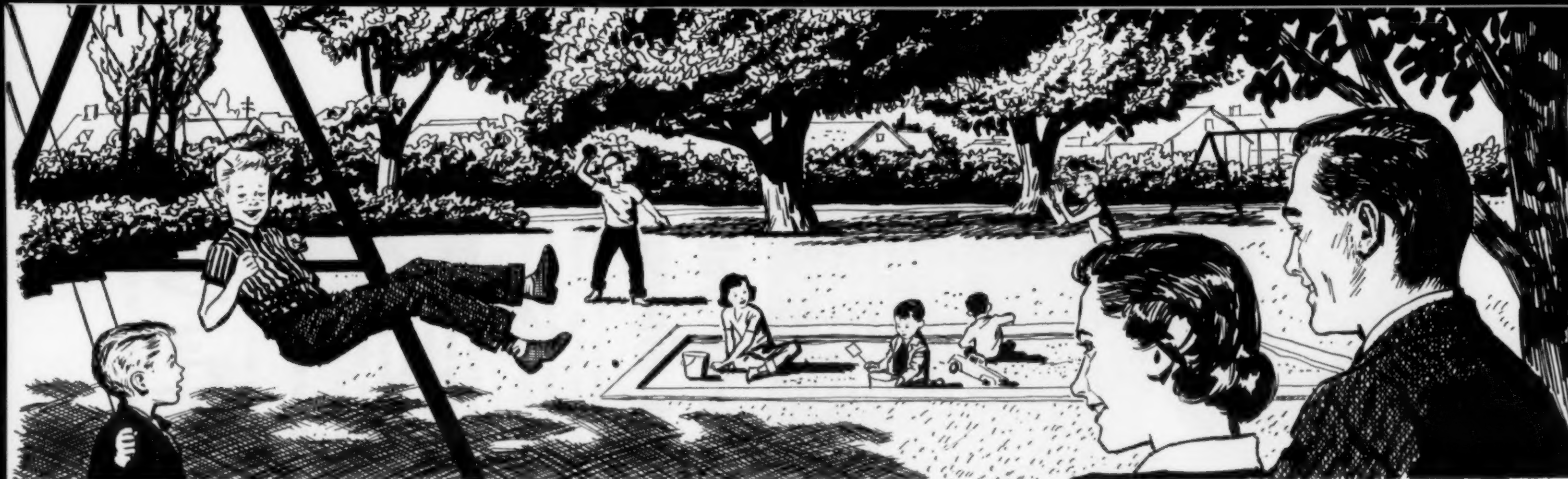
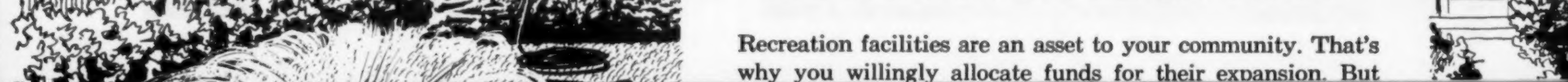


Playgrounds assured...

but what about their most precious possession...water?



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Recreation facilities are an asset to your community. That's why you willingly allocate funds for their expansion. But

because there just isn't enough water for expansion.

(*Continued from page 62 P&R*)

The Effect of Free Available Chlorine on Bacteria and Bacterial Viruses. L. FRIBERG & E. HAMMARSTROM. Nord. Hyg. Tidskr., **37**:1 ('56). Study was made of effect of free available chlorine on bacteria and bacteriophages in water. At pH 7.2 and temp. of 6°C, exposure for 1 min to a concn. of 0.025–0.05 mg/l chlorine effected a thousandfold reduction in number of typhoid, *sonnei,* and coliform bacteria, but concn. of 0.10–0.15 mg was necessary to effect same reduction in numbers of *Salmonella typhimurium, Strep. faecalis,* and *Staphylococcus aureus.* The coliform, *sonnei,* and *typhimurium* phages were reduced thousandfold by concn. of 0.04–0.07 mg/l free chlorine. Efficiency of chlorine in reducing numbers of bacteria and phages increased with decrease in pH value and increase in temp.—*WPA*

The Use of Ion-Exchange Resins to Reduce the Bacterial Content of Water. G. ROVAI. Igiene Mod. (It.), **49**:580 ('56). Ion-exchange resin was tested to see if it could reduce bact. content of water. As it contained both anion and cation resin these were tested separately, and were then combined in proportions of 2:1 against tap water artificially infected with coliform organisms. After filtration, samples were transferred to agar and also washings from resin immediately after filtration. From tables it can be seen that filtration had effect of reducing bact. content to about 2.5% of original. In another series of expts. water from shallow well was filtered through both anion and cation resins and also through sand granules of which were of same diam. as those of resin (1 mm.), idea being to det. whether diminution in bact. count was due to filtration *per se* or whether properties of resin itself were also important. Filtration through sand gave much less satisfactory results. In final series of expts. chem. tests for hardness and chlorides were carried out after filtration of up to 6 l. of water artificially infected. Hardness was not detected until 4 l. had been filtered, and chlorides which appeared at same time were rather less in expt. when proportion of cationic to anionic resin was 2:1. Author concludes that of 2 cationic resin was more efficient but that filtration of water through synthetic resins is very different from filtration through sand, not only from chem. but also from microbiological point of view. Thickness of sand filter is not stated, nor time taken in filtration.—*BH*

FILTRATION

Sand Filtration Studies With Radiotracers. D. R. STANLEY. Proc. Am. Soc. Civil Engrs., No. 592 ('55). App. and method used in investigations, under controlled lab. conditions, of factors affecting penetration of floc into and its removal from water in rapid sand filters are described. Radioactive iodine (I^{131}) was used as tracer for ferric oxide floc, and concn. in filter of gamma radioactivity absorbed in floc was detd. with Geiger tube connected to scaler. Calc. of parameters relating to concn. of floc in sand, depth of penetration of floc, and increase of head loss in filter are discussed. Results are given, with appended graphs, of influence of such factors as concn. of floc and floc particle size, hydrogen ion and other ion concn. in suspending water, size of sand particles and rate of flow of applied water on penetration index, defined as penetration in cm caused by passage into filter of 1 mg of iron per sq cm of filter area. Special tests made to study fundamental mechanisms involved in rapid sand filtration process are discussed.—*WPA*

Pressure Tank Filter Doubles Capacity. Chem. Eng., **63**:250 ('56). New high-rate pressure filter is described and illustrated. It has been found capable of operating at rate of 1–5 gal per sq ft per min. App. comprises rectangular filter leaves suspended from slotted plate within closed tank surmounted by dome. Water enters at bottom of tank, passes through leaves, depositing suspended solids on precoated surface, and flows upwards within leaves to dome where it is dischgd. through opening near top of dome. Any entrained air or gases which rise into dome are bled off through relief port. Leaves are backwashed when necessary by reversing flow. Unit is available in only 1 size, with capac. of 310 sq ft.—*WPA*

Head Loss Through Filter Beds During Backwashing. J. R. BAYLIS. Pure Water, **7**:102 ('55). Data given relate to head of water lost between sand-gravel junction and water above sand during backwash periods. —*PHEA*

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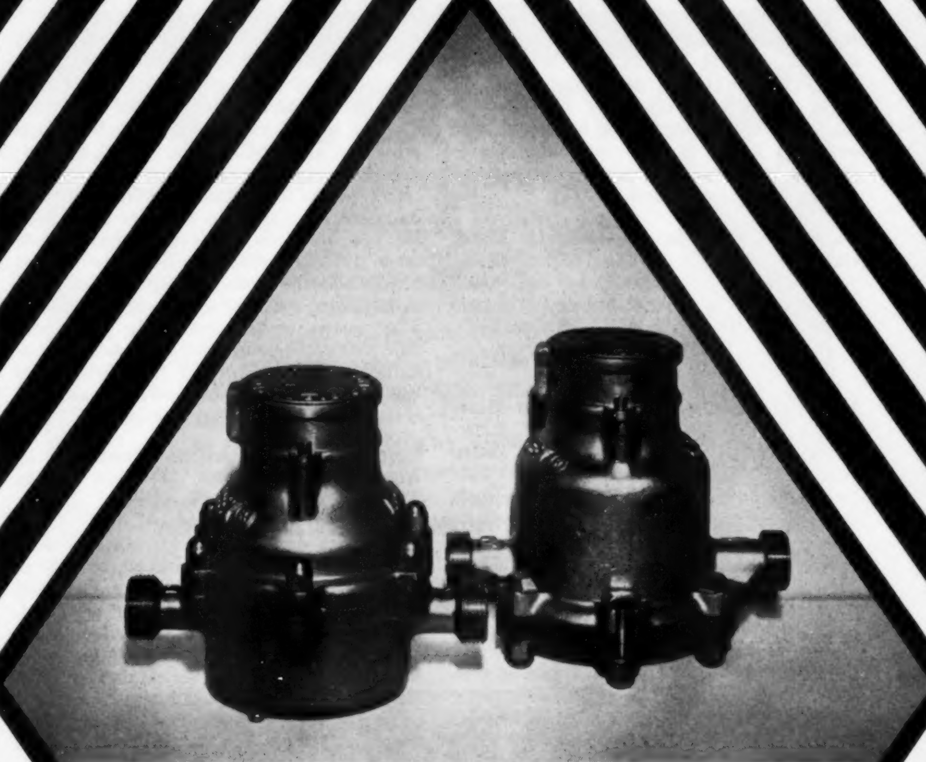

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Rapid-Rate Filter Design Criteria. D. E. Colvin. Bull. N. Dakota Wat. Wks. Conf., **24**:2 ('56). Design and construction of rapid sand filters is reviewed. No outstanding changes in design have been developed over past 20 yr. Author deals with considerations to be taken into account when designing rapid sand filters.—*WPA*

Flow of Water Through Granular Material. A. Profit. L'Eau (Fr.), **43**:161 ('56). Formulae are given for detg. diam. of avg. grains of material to be used in sand filters.—*PHEA*

HYDRAULICS

Hydraulic Conveying of Solids in Horizontal Pipes. D. M. Newitt, J. F. Richardson, M. Abbott, & R. B. Turtle. Trans. Inst. Chem. Engrs. (London), **33**:93 ('55). Description is given of lab. and pilot scale app., and materials and methods used, to obtain data for effects of particle size and density on head losses in a 1-in. diam. pipe over wide range of velocs. and concn. of solids. Results show that flow characteristics in hydraulic conveying in horizontal pipes depend on mean veloc. of flow, concn., mean size and density of solids, and on pipe diam. Theoretical equations are given relating pressure losses along pipe to these variables for different types of flow, and data obtained from expts. are correlated by these equations and applied to design of hydraulic conveying installations. Results obtained for mixtures of sands of 2 distinct sizes are also given and discussed.—*WPA*

Stream Flow: Polydimensional Treatment of Variable Factors Affecting the Velocity in Alluvial Streams and Rivers. C. Toebes. Proc. Inst. Civ. Engrs. (London), **4**:900 ('55). Necessity of polyfactor anal. in determination of pure influence of variable factors affecting mean veloc. in alluvial streams and rivers, and basic principles of theory and practice of such anal. are outlined. Application of polydimensional treatment to series of data, given in tables, to calculate mean veloc. of flow is explained. Criticism received from authorities in hydraulics and author's reply to these comments are incorporated in paper.—WPA

Experiments on the Flow of Sand-Water Slurries in Horizontal Pipes. R. A. Smith. Trans. Inst. Chem. Engrs. (London), **33**:85 ('55). Expts. were carried out to determine pressure drop when coarse, fine and mixed sand-water slurries were pumped at velocs. ranging from 3 to 8 fps through horizontal pipes 2-in. and 3-in. in diam. Exptl. installation is described and shown diagrammatically; results are expressed graphically and discussed in relation to Moody's correlation for pressure drop in straight pipes and to other published data. It is concluded that Moody's correlation is only applicable to closely sized particles and an approximation is suggested for determining the equiv. particle diam. Pressure characteristics of centrifugal pump show that its efficiency of handling slurry falls only slightly with increasing concn. of slurry.—*WPA*

Correlations for Use in Transport of Aqueous Suspensions of Fine Solids Through Pipes. K. E. Spells. Trans. Inst. Chem. Engrs. (London), **33**:79 ('55). Exptl. data derived from literature on flow through pipes, usually horizontal, of settling slurries consisting of mixtures of fine solid particles with water, have been collected. Dimensional anal. has been applied to obtain correlations for both min. and std. velocs. in terms of particle size, particle density, fluid density, slurry density and pipe diam., and these equations are discussed in relation to shape, size and behavior of particles, and pipe roughness and direction.—*WPA*

Some Effects of Upland Discharge on Estuarine Hydraulics. H. B. Simmons. Proc. Am. Soc. Civil Engrs., No. 792 ('55). Author discusses degree of stratification of fresh water and salt water in different types of estuaries. Where there is significant stratification magnitudes, directions, and durations of currents near surface are appreciably different from those near bottom. Normally in stratified estuary net movement seaward at surface of water is greater than at bottom. Author concludes from consideration of data from several estuaries that rough prediction can be made of degree of stratification by considering flow of fresh water into estuary and mean tidal prism (defined as vol. of water flowing into estuary from sea during avg. flood tide period). Where ratio of vol. of fresh water in tidal cycle of about 12–24 hr., to mean tidal prism, is of order of 1.0 or more, estuarine water will normally be highly stratified. Where

(*Continued on page 70 P&R*)

(*Continued from page 68 P&R*)

ratio is of order of 0.25 it will be partly mixed; and where ratio is appreciably less than 0.1 there will be no significant stratification. Author suggests that positions in estuary at which net deposition of solid matter will occur can be predicted from study of current velocs. at surface and bottom. In unstratified estuary deposition may occur anywhere throughout the length of estuary where local conditions of water movement (such as eddying) favor it. In a well stratified estuary net upstream movement of water near bottom is greatest at seaward end; at landward end net movement at all depths will be seaward. At some point between these positions net movement at bottom is neither landwards nor seawards and deposition will tend to occur immediately upstream of this point. Theory is illustrated by reference to Savannah Harbor.—*WPA*

The Flow of Fluids Through Beds of Spherical Particles. G. C. A. PECK & S. B. WATKINS. Industr. Chem. & Chem. Mfr., **32**:122 ('56). Apparatus and technique used to study flow of fluids through beds of spherical particles in fixed bed and fluidized bed regions are described. Effects of initial voidage in fixed bed on fluidizing point and fluidized region were investigated and motion of bed of particles was studied in detail. Correlation of data obtained is discussed.—*WPA*

Measuring Flow in Pipelines by an Aerofoil. C. E. R. SAMS. Engineering (London), **182**:330 ('56). Classical methods of flow measurement in pipes by means of orifice plates or Venturi tubes involve substantial head losses where high flows are involved. To overcome this, aerofoil flow meter has been developed, which has addnl. advantages that cost of installation is low, it can be used anywhere in a pipe system, it can be used for measuring widely varying flows, and it can be readily dismantled for cleaning without stopping plant. Unit is based on measurement of pressure difference between upstream tapping in region of undisturbed flow and downstream tapping on unit itself, but as

(*Continued on page 74 P&R*)

(*Continued from page 70 P&R*)

unit takes form of aerofoil small in relation to cross section of pipe, it introduces very little flow disturbance in main body of liquid. Design and operation of aerofoil are described and illustrated.—*WPA*

New Methods in Flow Measurement. O. Wilser. Wasserwirrsch. Wasser Tech. (Ger.), **6**:4 ('56). Author describes method of measurement of flow in which measurements are made at 2 vertical points only. These are at surface and at 0.38 of depth. Method of calcn. is described.—*WPA*

Measurements of Flow in Pressure Pipes Using Radioisotopes. E. Sons. Gas- u. Wasserfach (Ger.), **97**:672 ('56). Author describes application of measurement of flow by radioactive isotopes to flow in pressure pipes of sewage pumping plant. Expts. were made in pressure pipes of 4 pumping plants. Radioactive soln. was introduced under pressure at distances of between 5 and 60 m from pumps and measurements by Geiger counter were made at 2 points on each pipe. Arrangements for adding soln. and installation of counters are shown in diagrams. Measurements were made during normal operation and at different levels of output of pumps. Results show that method is applicable to these conditions and has advantages over other methods in applicability and accuracy. It can be used to test output of pumps during operation and to detect any deterioration in efficiency. Results also give information about distr. and mixing of radioactive mass during flow through pipe which can be applied to flow of any intermittent addition of such substances as acids and poisons.—*WPA*

Flow Into a Well by Electric and Membrane Analogy. C.-H. Zee, D. F. Peterson, & R. O. Bock. Proc. Am. Soc. Civil Engrs., No. 817 ('55). Report is given of study of radially symmetrical, unconfined flow to well. Using app. described in text, which combined electrical analogy for hydraulic flow with membrane analogy for free surface, data were obtained from lab. runs and 1 field test. Exptl. results are used in conjunction with observations from other investigators to obtain empirical relationships between flow to well and geometric variables.—*WPA*

Measurement of Water. C. Truelsen. Bohrtech. Brunnenbau (Switz.), **6**:11 ('55). Author deals with measurement of water in vessels as used in pump expts. and by overflow and Venturi meters in open channels. Conditions in which different processes can be used are discussed and formulae, tables, and graphs for calcn. of amt. of water are given. In closed pipes Venturi meters or Deacon or float meter can be used. Adaptation of latter for use in tube wells is described. If total amt. of water continuously flowing through closed pipe is required, Voltman or vane recorders are used. Measurements can be automatically recorded by electrical means.—*WPA*

The Problem of the Vertical Rate Curve in Natural Streams. M. Lippke. Osterr. Wasserwirtsch. (Aust.), **7**:213 ('55). Author describes relation between flow in pipes and flow in open streams and gives curves and equations for calcn. of flow with examples from measurements in various rivers.—*WPA*

Thermal Flow Meters for Small Flows and High Pressures. H. R. Ronnebeck. Engineer (London), **200**:538 ('55). Design and performance of 3 thermal flowmeters for measuring the rate of flow of liquids flowing at rates below those which can be measured by rotameters, and at high pressures, are described. One of meters described is unaffected by pulsating flows.—*WPA*

Graphic Design of Alluvial Channels. N. Chien. Proc. Am. Soc. Civil Engrs., No. 611 ('55). Design curves, based on Einstein's theories for alluvial channel flow and its relation to sediment transport rate, are given for determination of channel depth and slope to carry given unit discharge and sediment load. Curves are applied to determine river flow conditions caused by diversion of flow, construction of dams, contraction of channels, elimination of river forks, and cutoff of bends. Ineffectiveness of curves in relation to design of irrigation canals is discussed. In prepared discussion of paper, E. W. Lane comments on absence of any method for selecting width of channel in design curves, and discusses factors influencing best width in both natural and artificial channels.—*WPA*

Separation of a Constant Fraction of Water at a Measuring Weir. W. Liebs. Gas- u. Wasserfach (Ger.), **96**:170 ('55). Author

(*Continued on page 76 P&R*)

(*Continued from page 74 P&R*)

describes design of overflow weir planned to measure runoff from agricultural land and to make it possible to determine content of suspended matter. After examining possibilities of various shapes of weir, a circular topped weir was used. On downstream slope, 20 cm below crown, 2 plates were fixed 3 cm apart. Water entering this slit flowed to pipe apart from main flow. Expts. showed that proportion sepd. from main flow by this method was satisfactorily constant at different rates of flow. An illustrated account is given of design of exptl. plant and application of design to natural conditions and to various uses is discussed.—*WPA*

Discharge Coefficients for Gates and Valves. C. W. THOMAS. Proc. Am. Soc. Civil Engrs., No. 746 ('55). Adaptation of devices for controlling water flow to serve also as metering stations is considered, and available information on calibration of certain types of control devices by means of models and by prototype measurements is examd. Representative examples are given, accompanied by diagrams of devices and their discharge coefficient curves, of comparisons of model and prototype calibrations of valves and gates incorporated in dams in Egypt and USA. Accuracy of calibrations, and reasons for any nonconformance between laboratory and field observations are discussed.—*WPA*

The Measurement of Instantaneous Flow Rates and of Levels. Fundamentals and Principles of Application. P. FROGER. Génie Chim., **75**:148 ('56). Author reviews principles of measurement of instantaneous flow rates, and indicates possible sources of error. Chief methods for measuring water level under various conditions are described and illustrated.—*WPA*

Critical Flow Meters (Venturi Flumes). A. BALLOFFET. Proc. Am. Soc. Civil Engrs., No. 743 ('55). Theoretical anal. of measurement of flow in open channels by critical flow meters is given, and types of flumes which have been developed are reviewed. Details are given of models used and expts. carried out at hydraulics laboratory of Buenos Aires University to develop standardized equip., economical to install and simple to use, particularly when controlling water use in irrigation systems. Results of expts. and their application to open-channel discharge measurements are described. Extrapolation of lab. results to full-scale models operated in field appears to be possible.—*WPA*

How Radiotracers Are Used in Measuring Fluid-velocity Profiles. F. M. RICHARDSON, J. K. FERRELL, H. A. LAMONDS, & K. O. BEATTY. Nucleonics, **13**:21 ('55). Method whereby rate of flow of liquid in tube can be measured, using radioactive isotopes, is described. This enables cross sections of rates of flow and thickness of liquid to be calcd. Rate of flow of liquid in center of tube is much greater than that at sides, and latter was previously very difficult to measure, as all methods developed involved disturbance of liquid. This method avoids disturbance of liquid, and veloc. measurements to within 0.002 in. from wall of circular tube can be obtained. Vertical tube was filled with liquid, and allowed to stand for at least 30 min to ensure thermal equilibrium. Lower part of tube was then filled with soln. of radioactive tracer, and upper part with tracer-free soln. Flow was brought quickly to constant veloc., and as tracer-free soln. displaced other, counting rate was measured. Detailed description of app. used to measure counting rate and veloc., is given, with diagrams. Counting was begun just before flow was started, and was continued until counting rate dropped to constant level. Aqueous solns. of glycerine and sodium carbonate were used, and results are shown in graph. Curves conform to predicted pattern, but deviate from it slightly when there is only very thin layer of tracer soln. This is thought to be due to diffusion of trace element into other soln.—*WPA*

Rational Evaluation of Current Meter Measurements in Large Cross-sections. H. B. RAFFAY. Osterr. Wasserwirrsch. (Aust.), **8**:34 ('56). Time required for evaluation of measurements of large flows can be reduced and accuracy of results increased by use of rational methods. Author has developed and tested process for calcg. rates of flow from time recorder strips. Comparisons are made between this method and methods previously used.—*WPA*

The Electrochemical Process of Flow Measurement. M. PLATZL. Osterr. Wasserwirtsch. (Aust.), **8**:11 ('56). Account is

(*Continued on page 78 P&R*)

(*Continued from page 76 P&R*)

given of difficulties of current meter measurements, especially in turbulent streams, and of use of salt diln. and color diln. methods. Author then deals with use of cond. measurements and development known as "relative diln. method." Electrochemical methods are still in exptl. stage and app. for practical use with necessary sensitivity and accuracy is lacking. Advantages of such methods include possibility of accurate control of mixing of salt soln. with stream water and fact that measurements can be made on spot. Difficulties caused by effects of temp. and their compensation are discussed in detail. Illustrated account is given of development and design of app. for electrochemical methods and method of evaluation, based on exhaustive investigations, is described. Finally, practical use of method is briefly described. —*WPA*

The Foxboro Magnetic Flow Meter—Characteristics and Design Considerations. T. C. Chitty. Proc. 6th Ann. Southeastern Symp. Industrial Instrumentation, Univ. Fla., **9**:12 ('55). Basic theories regarding design and operation of magnetic flow meters for measuring rate of flow of any material containing electrically charged particles are expounded. Design features of Foxboro a-c electromagnetic flow meter are described, and its advantages, its independence of variable factors such as viscosity, turbulence, suspended solids, pressure, and pulsating flows, its limitations, and interfering factors are discussed. Guaranteed accuracy of flow meter is given as ±1 per cent—*WPA*

Turbulent Flow in Smooth and Rough Pipes. T. Constantine. J. Inst. Munic. Engrs., **82**:401 ('56). Author describes briefly laminar and turbulent flow in pipes, suggests convenient method for designing pipes, and compares most commonly used empirical formulae.—*WPA*

RADIOACTIVITY

Mobile Unit Rids Water of Radioactivity. Chem. Eng., **63**:130 ('56). Mobile unit for treatment of water contaminated with radioactivity has been developed by US Army Engineers. Unit is available in 3 sizes, with capacs. of 600, 1,500, and 3,000 gph. Treatment comprises coagulation with pulverized limestone, filtration through diatomaceous earth, and disinfection, and will remove 85% of mixed fission products. Greater removal of fission products can be achieved by preliminary treatment with clay or by subsequent treatment by ion exchange.—*WPA*

The Artificial Radioactivity in Rain Water Observed in Japan from May to August 1954. Y. Miyake. Papers Meteorol. & Geophys. (Jap.), **5**:173 ('54). Rain water and dust samples collected at 10 stations located throughout Japan were analyzed for radioactivity. Samples were collected from May to Aug. 1954 following H-bomb expts. at Bikini atoll. Max. activity observed was 0.5×10^{-8} curie per liter observed in sample of rainwater collected at Kyoto University on May 16.—*PHEA*

Removal of Radioactive Fallout From Water by Municipal Water-treatment Plants. R. Eliassen & R. A. Lauderdale. US Atomic Energy Comm. **TID-7517**, Part 1a, p. 19 ('56). Samplings of raw water and water treated with alum, lime, and activated C at Lexington, Ky., showed that significant radiation fallout occurs only after rainfall following nuclear explosion. Increased turbidity of water does not increase percentage reduction of radioactivity. Reduction appears to decrease with increasing age of fallout material. Small amts. of radioactivity persist in impounded supplies or reservoirs for considerable periods after nuclear explosion. —*CA*

The Removal of Radioactive Particulate Matter From Water by Coagulation. N. C. Burbank Jr., R. A. Lauderdale, & R. Eliassen. US Atomic Energy Comm. **NYO-4440** ('55). Radioactive particulate matter in rain-out consists of debris from fission reaction and convected soil which is fused in detonation. Particles range from 0.0005 to 11μ with 50% within range of 0.2μ or larger. Suspended particulate matter shows preferential adsorption of anions upon its surface, while similarly adsorbed cations are held more loosely. Removal of particles with either alum or chlorinated copperas occurs through action of particles serving as nuclei for formation of hydrous oxide flux in alk. media. Presence of adsorbed layer of sulfate ions on radioactive particles increases production of nuclei and improves removal efficiency. These anions are ac-

(*Continued on page 80 P&R*)

(Continued from page 78 P&R)

quired by microcryst. floc in process. Turbidity in water greater than 5 ppm. improves coagulation. Removal of particle matter by softening with lime-soda ash is accomplished by the pptn. of calcite and (or) brucite in chains and aggregates about particle. Attachment is similar to that of hydrous oxide flocs, and crystal is attached at corner or edge of face, active surface of crystal growth. —*CA*

Effect of 1955 Nuclear Weapon Tests Series on Radioactive Monitoring Programme. B. L. Rosenthal. Sanitalk, **4**:19 ('56). Effects of radioactive contamination, produced by fallout from atomic detonations during nuclear weapon test series at Las Vegas in spring of 1955, on surface waters and water treatment plants in Massachusetts, were studied. Measurements of radioactivity in samples of rainfall, of Merrimack R. water at intake to Lawrence city water works, and of Cochichewick Brook, which is fed from lake Cochichewick, source of water supply for North Andover, were made. Detn. of amt. of radioactivity passing through treatment plant at Lawrence was made by examn. of rapid sand filter effluent; treatment at Lawrence works consists of coagulation with lime and alum, chlorination, sedimentation, and filtration. Results of these detns., which are presented in tables and graphs, show that there is increase in radioactivity of rainfall following atomic detonations; that increase in radioactivity of surface waters above normal background of streams was closely related to activity of pptn.; and that residual activity after passage of Merrimack R. water through Lawrence treatment plant was composed of background activity and some activity resulting from fallout. It was also apparent that the higher radioactivity of intake water the greater was removal by treatment. It is pointed out that in no case did activity recorded in samples approach permissible level of activity for water used as source of domestic supply.—*WPA*

Effects of Low-Level Radioactivity in the Columbia River. C. Henderson, G. G. Robeck, & R. C. Palange. Public Health Repts., **71**:6 ('56). Environmental sanitation problem for new atomic age may be created by dischg. of radioactive byproducts of nuclear reactions into surface streams. USPHS conducted water qual. studies on Columbia R. over period extending from mid-1951 to mid-1953. One of principal objectives of studies was to det. effects of radioactivity on phys., chem., and biol. characteristics of stream. Following major conclusions regarding radioactivity in Columbia R. are drawn from USPHS studies of 1951–53: [1] Low-level beta activity has had no adverse effect upon numbers and species of aquatic organisms in Columbia R. [2] Radioactivity levels in plankton and attached algae are directly dependent upon levels in river water. [3] Radioactivity levels in aquatic animals vary with their metabolic rates (which in turn vary with water temps.) and with radioactivity levels of materials upon which they feed. [4] Migratory species in Columbia R. such as salmon, adults of which do not feed in fresh waters, have low radioactivity levels at same time that levels in resident species are high. [5] Radioactive materials are concd. in all parts of body of fish. Activity levels, however, are about 10 times higher in scales, bones, and internal organs than in edible parts, such as muscle and skin. [6] Since aquatic organisms conc. specific radioisotopes such as phosphorus 32 many thousand times above levels in water, use of these organisms for human or animal consumption presents potential public health problem. However, to date levels of radioactivity in flesh of Columbia R. fish are not dangerously high.—*PHEA*

TREATMENT—GENERAL

Modern Chemical Treatment of Domestic and Industrial Water Supplies. P. Hofer. Gesundh. Ing. (Ger.), **76**:270 ('55). Author describes requirements of satisfactory water supply and gives detailed account, illustrated by plans and photographs of plant, of modern methods of chem. treatment for removal of iron, manganese, aggressive carbon dioxide, hardness, salts, and taste, odor, and color, and for disinfection.—*WPA*

The Purification of Water on a Small Scale. R. N. Clark. Bul. World Health Organization, **14**:820 ('56). Author points out 3 general methods commonly used for purification of small water supplies. There are boiling, chemical disinfection, and filtration. Boiling is safest method though chemi-

(Continued on page 82 P&R)

(*Continued from page 80 P&R*)

cal disinfection (especially with chlorine or iodine) has advantage of reducing possibility of recontamination. Filtration, alone, is least desirable method. Advantages and disadvantages of all 3 methods are discussed. Conditions desirable for use of each of disinfection techniques as well as directions for their application are summarized.—*PHEA*

Water Treatment and Ion Exchange. J. Ungar. In review of water treatment, short descriptions are given of treatment processes for removal of suspended and dissolved materials from water in relation to use for which water is intended; these processes include coagulation and filtration, removal of dissolved gases and of iron and manganese, and softening by lime-soda processes and by ion exchange using zeolites or synthetic cation-exchange resins. Development of cation-exchange resins in hydrogen form and of anion-exchange resins, and their use in multistage and mixed-bed processes for demineralization of water is summarized. Quality of effluent which may be obtained from mixed-bed units, or from combination of ion-exchange processes is described.—*WPA*

The Treatment of Doubtful Waters for Public Supplies. N. J. Pugh. J. Inst. Water Engrs., **11**:17 ('57). Study of characteristics of Severn R. emphasizes necessity for flexibility in plant operation and continuous supervision of treatment works. Satisfactory water acceptable to consumers is emphasized as shown by research in Coventry Corporation water undertaking. General interests of water works industries demand extensive and fundamental researches which may be carried out in universities and colleges and central research organization with industry.—*CA*

Stabilizing the Composition of Water in Treatment by Coagulation. L. A. Kulskii & M. A. Shevchenko. J. Chim. Ukraine (USSR), **19**:215 ('53). In expts. on treatment of natural waters with aluminium sulfate and chalk, 100 mg of aluminium sulfate and 176 mg of chalk in aq. soln. or suspension were used per liter, with mixing time of 15 min and linear speed of water of 0.3 m per sec. Chalk was best added after aluminium sulfate. Best addition is 250 mg of 30% soln. of aluminium sulfate and stoichiometric amt. (146 mg/l) of chalk.—*WPA*

The Addition of Flocculating Agents for Improving the Treatment of Ecker Water. W. Wiederhold & F. Hiebenthal. Gas- u. Wasserfach, **98**:225 ('57). Ecker reservoir water impurities vary widely, especially amt. and condition of humic acids, owing to swampy region in drainage area. Difficulties were encountered with rapid sand filters that could not be avoided with usual flocculating agents; the addn. of bentonite, clay, or active silica even made filtration more difficult. Best flocculating agent found was a 1% soln. of yellow dextrin, added at rate of 2 mg/l. With this flocculating agent, length of filter cycle was at least doubled, with satisfactory effluent throughout. Even better results were secured with special dextrin product (D 100) which gave an opalescent rather than clear soln. as with yellow dextrin. Filtration rate could be increased with use of this special product.—*CA*

CHEMICAL ANALYSIS

Determination of Dissolved Oxygen in Water Containing Reducing Substances. I. Davies et al. Analyst (Gr. Br.), **81**:113 ('56). Effect of interfering substances on results obtained by Winkler method on DO in water is shown. System of ion-exchange columns is proposed in which interference is removed while sample is being taken, thus enabling Winkler method to be applied without modification.—*CA*

Hydrogen Sulfide—Its Meaning in Water Analyses. The Betz Indicator, **25**:2 (Feb. '56). Hydrogen sulfide gas is poisonous although no harmful effects result from amt. of hydrogen sulfide present in water soln. Hydrogen sulfide has very objectionable odor and imparts corrosive characteristics to water. Detection of hydrogen sulfide is easily accomplished even in low concns. due to characteristic odor. However, actual quant. determination requires skill due to difficulty of collecting representative sample. Elimination of hydrogen sulfide from water involves individual study to determine most efficient and economical method. Each method of removal discussed has advantages and disadvantages. Best method of removal in any individual case is determined by such factors as total sulfide content of water, alkalinity, desired or required effluent sulfide concn. use or purpose

(*Continued on page 86 P&R*)

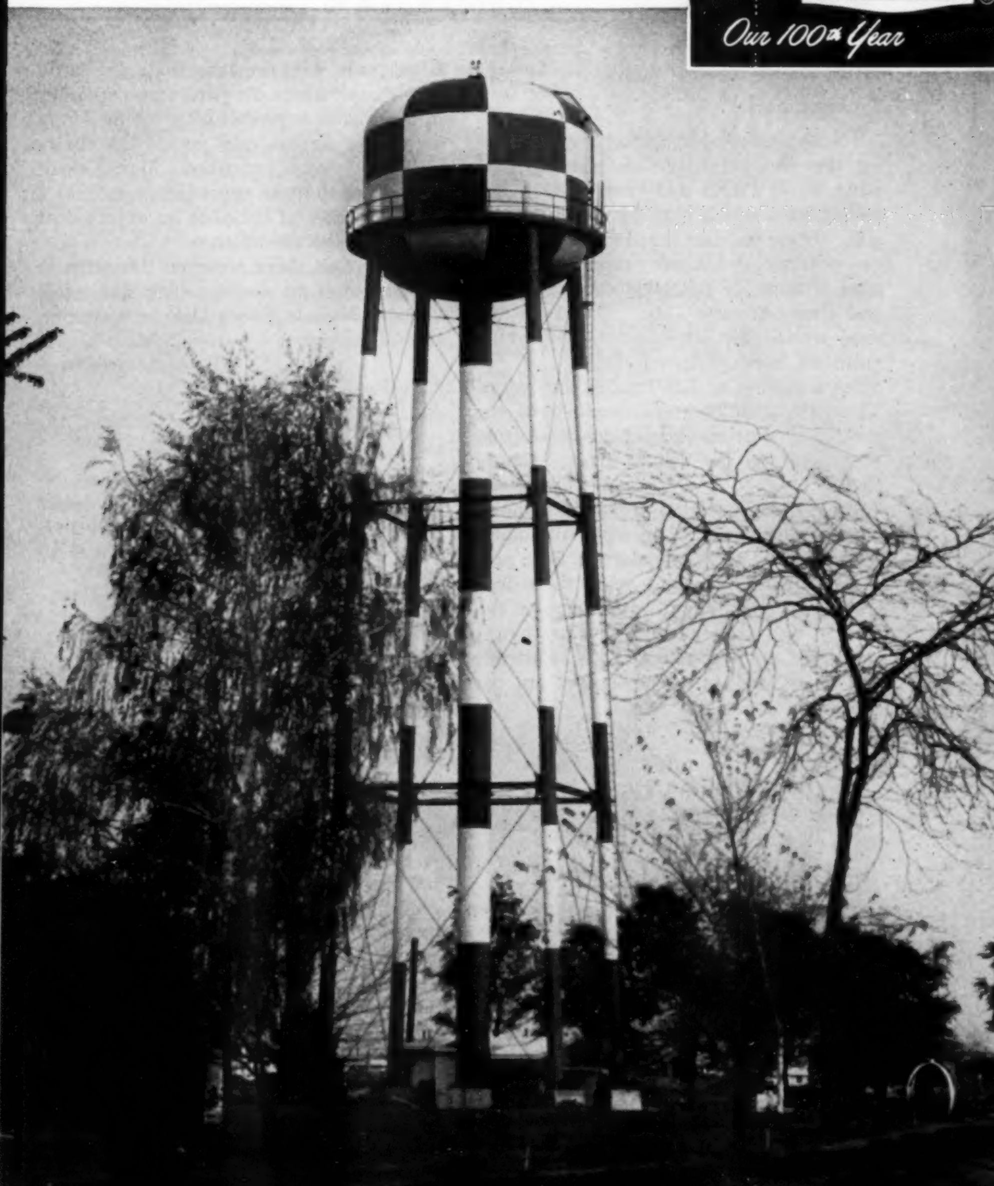
(*Continued from page 82 P&R*)

for which water will be employed and existing plant equip.—*PHEA*

Detection and Determination of Traces of Polynuclear Hydrocarbons in Industrial Effluents and Sewage. IV. The Quantitative Examination of Effluents. P. WEDGWOOD & R. L. COOPER. Analyst (Br.), **81**:42 ('56). Discharges into sewers of effluents contg. oil are greater potential source of these compds. than spent ammoniacal liquor from gas works. Carburetted water-gas effluent is example of effluents contg. gas oil that has been subjected to cracking in gas-producing plant. Method for detecting traces of polynuclear hydrocarbons has been described.—*CA*

The Determination of Dissolved Oxygen in Water with Leuco Indigo Carmine. K. WICKERT & E. Z. JAAP. Anal. Chem., **145**:338 ('55). A method is described for determination of D.O. in concns. of 3–50 μg per l. Leuco indigodisulphonic acid, prepared by reduction with zinc of an ammoniacal solution of indigodisulphonic acid, is added to sample, and color is measured photometrically using yellow filter. Limits of interfering substances are given, and existing methods for detn. of oxygen in water are reviewed critically.—*WPA*

The Biochemistry of Urochrome and Tests for Its Presence in Drinking Water. H. O. HETTCHE. Gesundh. Ing., **76**:309 ('55). Some particulars are given of biochemistry of urochrome in particular relation to causation of endemic goitre, for it is considered to be possible that urochrome, by combining with copper which is believed to be essential for adequate functioning of thyroid gland, may play part in this causation. Hypothesis that iodine lack is cause of endemic goitre cannot be substantiated in all instances of the disease and it has been possible to demonstrate that from waters highly polluted with animal matter there can be obtained materials, from which urochrome and other substances can be isolated, that induce goitre when administered to rats. With this theory in mind, author has developed 2 techniques, details of which are given, for the detn. of urochrome in water. These methods are based on adsorption of urochrome by aluminium hydroxide or by aluminium oxide, elution with formic acid and ultimate determination of amt. of urochrome by colorimetric process.—*CA*



Correspondence

Miles and Females

To the Editor:

I was interested in seeing the statistics for the Atlantic City Conference (June issue, p. 42 P&R) and have made a few calculations which may be of interest to you. These indicate that individuals from the continental United States traveled a total distance of 4,500,000 miles to go to and from Atlantic City. Based on the total number in attendance, this would mean an average travel distance of 750 miles one way, or 1,500 miles both ways. Thus, as naturally would be expected, the greater proportion of delegates came from areas not too far distant from Atlantic City.

I was also interested in the table showing the attendance of men versus ladies. At first glance, I was under the false presumption that in recent years there was a greater percentage of attendance on the part of our "better halfs." But when I calculated the percentage of ladies attending in comparison to the total, I got the following results:

Year	City	Per Cent Ladies
1957	Atlantic City	21.8
1956	St. Louis	20.1
1955	Chicago	19.8
1954	Seattle	25.5
1953	Grand Rapids	19.3
1952	Kansas City	19.4
1951	Miami	25.8
1950	Philadelphia	16.4
1949	Chicago	19.0
1948	Atlantic City	20.9

You will see that the proportion of ladies is uniformly in the neighborhood of 20 per cent, with the exceptions of Seattle and Miami, where the percentage of ladies in attendance exceeded 25 per cent. Perhaps these figures may permit the chairman of the Convention Management Committee to make approximate estimates of the number of ladies to be expected at future annual meetings.

I note that there were no delegates in attendance at the meeting from five states —Idaho, Nevada, South Dakota, Vermont, and Wyoming.

E. A. SIGWORTH

New York, N.Y.
Jun. 4, 1957

Sig's statistics simply prove that, regardless of sex or distance, you'd better be at Dallas in 1958. Texas demands more males and more miles, as well as more better fifths.—ED.

AWWA Can Get 'Em Up

To the Editor:

Now that its presentation is long past, the story of how my paper was actually written appears extremely amusing, but it certainly was not so during the 3 months in which it occupied my mind. In addition to my duties of supervising crews in the maintenance of our entire water and sewer systems, I have been responsible for the inspection of all utility construction in new subdivisions, as well as our own construction, and, with the rapid expansion of our system during the past few years, this has been a 7-day-a-week job—right now, a 40-hr week would seem like a vacation!

(*Continued on page 90 P&R*)

Correspondence

(*Continued from page 88 P&R*)

When, 3 months before our Section meeting, I was requested to prepare a paper, I was very proud to have been asked and determined to do a first-class job of it. But there were just not enough hours in the day, or days in the week, to do all that I wished, so the Sunday evening before the meeting caught me without one word of my paper written, although I had prepared a partial outline. The paper was scheduled to be read the following Friday morning, and at this point I was ready to drop the whole thing, but I did not think it right to duck out on a responsibility I had accepted. I decided to write a description of what we do and let it go at that—it wouldn't be technical and it wouldn't be good, but at least it would be a paper and would occupy the 30 min of the program allotted to me.

On Monday morning I arrived at my office at 4 AM and began to write. At 7 AM I had to leave to get my men started at work, so the few pages written were put on the typist's desk. The balance of the day was so completely occupied with other work that it was impossible to return to my paper. Tuesday, Wednesday, and Thursday were identical—the only time free for my paper was 4–7 AM. The Section meeting began Wednesday morning; I reached it at noon. The same was true Thursday, and I could not remain for the cocktail hour and banquet, as I had to get back to see if the girl had been able to type my manuscript. Fortunately, she had; my first reading of the complete manuscript was at 9 PM on the day before it was to be presented.

The following morning I managed to arrive at the meeting at 9, having made a few penciled corrections on my manuscript on the train. The period until my presentation at 11 AM was certainly one of apprehension and trepidation! Even my boss had not the slightest idea of what I had written. When the paper was finally presented, it was very gratifying to find the audience so attentive, and, to my surprise, I actually enjoyed reading my paper to the meeting.

A JOURNAL AUTHOR

On our author friend and others like him, AWWA depends not only for worthwhile programs and good Journal articles, but for all the other tasks that make it possible for AWWA to work toward higher standards of water works practice. We'll probably not advertise "Join AWWA and Get Less Sleep," but, if less sleep is what it takes, we could be coaxed into supplying the coffee. As a matter of fact, perhaps a coffee club would be in order—the MODEL club, Midnight Oilers and Dawn's Early Lighters, that is.—ED.

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Section Meetings

Nebraska Section: The Cornhusker Hotel in Lincoln was again the scene of the Nebraska Section's annual meeting on Apr. 24–26. As usual, this meeting was conducted together with the Utilities Section of the League of Nebraska Municipalities. Those attending were kept quite busy with a schedule of technical papers which were very well received. [A list of the papers presented will appear in the December 1957 JOURNAL.]

At the business meeting, routine matters of Section business were discussed, and the results of the letter ballots for the election of officers were announced. George H. Beard was elected chairman; M. L. Sievers, vice-chairman; and John E. Olsson, secretary-treasurer. Retiring Chairman Carl Fisher automatically became a member of the Board of Trustees. Bert Gurney carries on as national director. The Fuller Award Committee elected to make no nomination for the Nebraska Section for this year.

At the evening banquet, certificates were presented to more than 400 employees of municipal utilities in Nebraska who have given faithful service for 25 years and over. This procedure, new this year, will be followed at each subsequent annual meeting. While these certificates were being presented, a severe storm was blowing outside and a tornado passed within 10 miles of Lincoln. This news filtered into the banquet room and caused some alarm among the utility superintendents present at the meeting. A considerable amount of damage was done to nearby Milford. James A. Bowman, of the Standard Oil Co. Research Lab., provided a program entitled "Fire Magic," which proved to be very interesting and captured the attention of all in attendance at the banquet.

JOHN E. OLSSON
Secretary-Treasurer

Pacific Northwest Section: A record attendance of 350 men and 114 ladies heard Gerrit Vander Ende, chairman of the Tacoma, Wash., Public Utility Board, welcome them to Tacoma for the Section's 30th annual meeting, May 2–4, 1957. Subjects covered at the technical sessions included: recreational use of reservoirs, water demands by the paper and canning industries, population growth problems, effect of high rates on water consumption, induced infiltration, ground water resources, earthquake damage to wells, and automatic control equipment. [A list of papers and authors will appear in the December 1957 JOURNAL.]

Life Membership certificates were presented by Secretary Jordan to Edgar W. Thompson and A. H. Labsap. The Powell-Lindsay Award was given to John L. Boyle, regional sales manager for Pacific States Cast Iron Pipe Co., and the Fuller Award nomination went to Arthur S. G. Musgrave, municipal engineer, Oak Bay, B.C.

The Section officers for the next year are: chairman—Henry J. Donnelly, Bellingham, Wash.; vice-chairman—Herbert C. Clare, Portland, Ore.; trustee—A. H. Perry, Vancouver, B.C.; director—E. Jerry Allen, Seattle, Wash.; and secretary-treasurer—Fred D. Jones, Spokane, Wash.

FRED D. JONES
Secretary-Treasurer

NEW MEMBERS

Applications received May 1–31, 1957

Adams, William James, Regional Engr., Underwood McLellan & Assocs., Inc., 207 Silver Hgts., Winnipeg 12, Man. (Jan. '57)

Angeline, Lawrence J., Foreman, Pumps & Storage, Water Div., 4848 S. L, Tacoma, Wash. (Apr. '57)

Angell, Glen V., Water & Street Supt., 1422 S. 5th, Dayton, Wash. (Apr. '57) *MRPD*

Apgar, William Lloyd, Jr., Salesman, Water Works Supply Co., State Highway #23, Pompton Plains, N.J. (Apr. '57) *D*

Ashlock, Joseph H., Chief Inspector, Water Bureau, Portland 4, Ore. (Apr. '57) *M*

Awde, Jack Edward, Research Engr., Johns-Mansville Research Center, Manville, N.J. (Apr. '57) *P*

Baxter, Malcolm N., Div. Engr. of Constr., Div. of Water, 600 Collins Park Ave., Toledo 5, Ohio (Apr. '57) *RD*

Beach, Donald G., Independence Township Water Dept., Clarkston, Mich. (Apr. '57) *MD*

Beck, Elmer E., Supt., Water Dept., Chesterton, Ind. (Apr. '57) *MPD*

Behrens, A. L., Maintenance Supt., Box 6545, Eagle Lake, Tex. (Apr. '57) *D*

Berhard, Warren K., Pres., Bernhard Eng. Sales Co., 309 Meadows Bldg., Dallas, Tex. (Apr. '57) *PD*

Beveridge, J. A., City Comr., City Hall, Moose Jaw, Sask. (Jan. '57)

Bingham, George R., Asst. Engr. of Water Supply, Wayne County Road Com., 7th Floor, City-County Bldg., Detroit 26, Mich. (Apr. '57) *MPD*

Black, Elwyn E., Supt., Vista Hgts. Water Dist., 295 S. View Pl., Salem, Ore. (Apr. '57) *M*

Blackwell, Edwin Hughes, Application Engr., Water & Waste Treatment Div., Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio (Apr. '57) *RPD*

Blair, Elwin, *Partner,* Alvin Blair & Co., 244 Paul Rd., Rochester 11, N.Y. (Apr. '57) *D*

Boden, Charles, Waterworks Supt., Saltfleet Water Area No. 4, Stoney Creek P.O., Ont. (Jan. '57)

Boonsboro Bd. of Water Comrs., Robert E. Lakin Jr., Chairman, Boonsboro, Md. (Corp. M. Apr. '57)

Bramhall, Richard A., Vice-Pres., S. Morgan Smith, Canada, Ltd., 330 Bay St., Toronto, Ont. (Jan. '57) *PD*

Brennan, T. H.; *see* Cramet, Inc. (Tenn.)

Brice, Lorrin S., Jr., Dist. Mgr., B-I-F Industries, Inc., 11 N. Pearl St., Albany 7, N.Y. (Apr. '57)

Brightman, Henry S., Exec. Vice-Pres., Schmieg Industries, Inc., Box 4701, Detroit 34, Mich. (Apr. '57)

British Columbia Water Rights Branch, Dept. of Lands & Forests, M. L. Zirul, Sr. Hydr. Engr., Improvement Dist. Sec., Parliament Bldgs., Victoria, B. C. (Corp. M. Apr. '57) *D*

Brooks, James Orville, Supt., Water Services, Water, Light & Power Dept., Springfield, Ill. (Apr. '57) *M*

Brown, J. Edwin, Civ. Engr., Haddin Davis & Brown Ltd., 1134—8th Ave. W., Calgary, Alta. (Jan. '57) *PD*

Browne, Thomas C.; *see* City of Colby (Kan.)

Burchell, Ernest J., Sales Engr., Victaulic Co. of Canada, Ltd., 5181 Wales Rd., Vancouver 16, B.C. (Jan. '57)

Callahan, Frank J., Director of Utilities, Lima, Ohio (Apr. '57) *M*

Campbell, Robert E., Sales Engr., A. P. Smith Mfg. Co., 5845 Fairfax Ave. S., Minneapolis, Minn. (Apr. '57) *R*

Capps, Earl L., Vice-Pres., Valves, Inc., 11544 Perkins, Los Nietos, Calif. (Apr. '57) *MD*

Capps, Paul E., Pres., Valves, Inc., 11544 Perkins, Los Nietos, Calif. (Apr. '57) *MD*

Cassanos, James George, 85 Pleasant St., Woburn, Mass. (Apr. '57) *RP*

Cavolt, Paul E., Sales Repr., Hersey Mfg. Co., 508 S. Monterey Pass Rd., Monterey Park, Calif. (Apr. '57) *MD*

Ching, Harold; *see* Kauai County (Hawaii) Waterworks Bd.

Christolear, L. K.; *see* City of Lamar (Colo.)

Clapp, Leonard F., Supt. of Water, 48 Wheeler Ave., Pleasantville, N.Y. (Apr. '57) *MD*

Coghill, J. B.; *see* Savine River (Tex.) Works of E. I. DuPont Du Nemours & Co.

Colby, City of, Thomas C. Browne, City Mgr., Colby, Kan. (Corp. M. Apr. '57)

Collins, Fred, Architect, 400 W. 5th Ave., Gary, Ind. (Apr. '57)

Cox, William H.; *see* New Castle County (Del.) Water Co.

Cramet, Inc., T. H. Brennan, Plant Engr., Chattanooga, Tenn. (Corp. M. Apr. '57) *P*

Crouch, Hubert J., Sales Engr., Infilco, Inc., Box 5033, Tucson, Ariz. (Apr. '57) *P*

Culbertson, Don M., Hydr. Engr., Water Resources Div., US Geological Survey, 510 Rudge-Guenzel Bldg., Lincoln, Nebr. (Apr. '57) *R*

Curtis, John Walther, San. Engr., Greeley & Hansen, 220 S. State St., Chicago 4, Ill. (Apr. '57) *PD*

Davis, John Elwood, Director, Haddin Davis & Brown Ltd., 1134—8th Ave., W., Calgary, Alta. (Jan. '57) *P*

DeSpain, Jean Leo, Prin. Engr., Olympia, Wash. (Apr. '57) *PD*

DeVore, Homer, Office Mgr., Carol City Utilities, Inc., Box 1267, Opalocka, Fla. (Apr. '57) *MPD*

Dibble, Edward Fitzgerald, Cons. Engr., 10½ W. Citrus Ave., Redlands, Calif. (Apr. '57) *MRD*

Dolph, Russell L., Water Supt., 424 Coolbaugh St., Red Oak, Iowa (Apr. '57) *MD*

Domas, Joseph J., Chief, Bureau of Design & Constr., Hackensack Water Co., 4100 Park Ave., Weehawken, N.J. (Apr. '57) *MD*

Durnin, George, Design Engr., Lescon, Ltd., Box 20, Don Mills, Ont. (Jan. '57)

Elliot, Edwin, Pres., Edwin Elliot & Co., Inc., 560 N. 16th St., Philadelphia, Pa. (Apr. '57) *D*

El Paso Natural Gas Co., A. H. Viescas, Supervisor Engr., Box 1492, El Paso, Tex. (Corp. M. Apr. '57)

Erickson, David M., Sales Engr., Layne-New York Co., Inc., 150 Denton Ave., New Hyde Park, N.Y. (Apr. '57) *RP*

Farmer, Edward Jack, Research Asst., Dept. of Economics, Colorado State Univ., Fort Collins, Colo. (Apr. '57) *R*

Feustel, Fred; *see* Fort Wayne (Ind.) City Utilities

Forbes, Cecil M., Jr., Sales Engr., James B. Clow & Sons, Inc., 224 N. 3rd St., Jacksonville Beach, Fla. (Apr. '57) *D*

Fort Wayne City Utilities, Fred Feustel, Gen. Supt., 308 E. Berry St., Fort Wayne, Ind. (Munic. Sv. Sub. Apr. '57) *MD*

Fox, Glenn J., Tenn. Coal & Iron Div., US Steel Corp., Fairfield, Ala. (Apr. '57) *M*

Francis, James Gordon, Civ. Eng. Assoc., Dept. of Water & Power, 207 S. Broadway, Los Angeles, Calif. (Apr. '57)

Fulton, George P., Chief Hydraulic Engr., Brown & Blauvelt, 468—4th Ave., New York, N.Y. (Apr. '57) *PD*

Garcia, Jose Raul, Cons. Engr., Edificia La Metropolitana #208, Havana, Cuba (Apr. '57) *MD*

Gentry, Willis E., Chief Engr., Brackenridge Park Station, 2300 Ave. B, San Antonio, Tex. (Apr. '57)

Gibbs, L. C., City Engr., 1056 Chehalis Ave., Chehalis, Wash. (Apr. '57)

Glacken, John Francis, Chief Engr., Water Dept., 250 Fresh Pond Pkwy., Cambridge, Mass. (Apr. '57) *MRPD*

(Continued on page 96 P&R)

(*Continued from page 94 P&R*)

Glencoe, Village of, James A. Williams, Director of Public Works, Village Hall, Glencoe, Ill. (Corp. M. Apr. '57) *MP*

Goddu, Robert F.; *see* Kennett Square (Pa.) Water Dept.

Golden, Thomas P.; *see* Russels Point (Ohio) Waterworks

Golitz, Helmut H.; *see* Sonoma Water & Irrigation Co. (Calif.)

Goode, Arlie H., Secy.-Treas., Yocum & Goode, Inc., 420 Lexington Ave., New York, N.Y. (Apr. '57)

Grasmere, Robert H., Owner-Mgr., Mountain Soft Water Service, 6 W. Parker Ave., Maplewood, N.J. (Apr. '57) *RP*

Graver Tank & Mfg. Co., Calvin G. Miller, Asst. to the Sales Mgr., 4809 Tod Ave., East Chicago, Ind. (Assoc. M. Apr. '57)

Greenhill, Jerome Harry, 6234 N.E. 2nd Ave., Miami 38, Fla. (Apr. '57) *PD*

Gull, Carl, Supt., Water Works, Colesburg, Iowa (Apr. '57) *PD*

Haas, Clarence Charles, Sales Engrs., Layne Western Co., 4430 Commercial Ave., Omaha, Neb. (Apr. '57)

Hall, Lewis Watson, Cons. Engr., 5601 Country Blvd., Little Rock, Ark. (Apr. '57) *PD*

Hanat, E. H., Development Engr., Salem-Brosius, Inc., Arch St., Carnegie, Pa. (Apr. '57) *PD*

Hannam, John W., Water Supt., Woodland, Wash. (Apr. '57) *MRPD*

Hausner, E. H., Mayor, Sinclair, Wyo. (Apr. '57) *P*

Hawkinson, Gilbert L., Dist. Service Engr., The Flox Co., Inc., 1409 Willow St., Minneapolis, Minn. (Apr. '57) *P*

Hyman, Albert A., Design Engr., Underwood McLellan & Assoc., 207 Silver Hgts. Shopping Centre, Winnipeg 12, Man. (Jan. '57)

Haysville, City of, John W. Trout Jr., Mayor, 245 Grand Ave., Haysville, Kan. (Corp. M. Apr. '57) *MD*

Hearn, Kenneth H., Mfger's Repr., K. H. Hearn Co., Box 2207, Martinsville, Va. (Apr. '57) *D*

Hickok, Eugene A., Ground-Water Geologist, Leggette, Brashears & Graham, 551—5th Ave., New York, N.Y. (Apr. '57) *R*

Hintgen, H. T., City Auditor, City Hall, Wahpeton, N.D. (Apr. '57) *M*

Hoatson, Donald Alexander, Chem. Engr., Babcock & Wilcox Atomic Energy Div., 1201 Kemper St., Lynchburg, Va. (Apr. '57) *P*

Hockaday, Alfred E., Sales Repr., Kennedy Valve Mfg. Co., Elmira, N.Y. (Apr. '57) *PD*

Honeycutt, Frank C., Jr., Design Engr., Forrest & Cotton, 600 Vaughn Bldg., Dallas 1, Tex. (Apr. '57) *PD*

Howlett, E. Stanley, Supt., Filter Plant, Raymond St., Potsdam, N.Y. (Apr. '57) *MPD*

Huffine, Herbert T., Salesman, Mueller Co., Decatur, Ill. (Apr. '57)

Hutchins, Harry, Pumping Station Supervisor, Water Dept., E. 2626 Nora Ave., Spokane, Wash. (Apr. '57)

Hylton, Carmon E., Supt. of Meters & Pumping Stations, 20 E. Salem Ave., Roanoke, Va. (Apr. '57) *RD*

Iraq Directorate General of Municipalities, A. Razak Shikarah, Director General of Municipalities, Ministry of Interior, Baghdad, Iraq (Munic. Sv. Sub. Apr. '57)

Irwin, William, Water Works Engr., Oelwein, Iowa (Apr. '57) *D*

Jackson, James O., Pres., Eng. Development Co., Box 249, Coraopolis, Pa. (Apr. '57) *PD*

Johnson, Richard F., Sales Repr., Ludlow Valve Mfg. Co., Inc., 8916 Oakland Ave., Minneapolis, Minn. (Apr. '57) *D*

(*Continued on page 98 P&R*)

(Continued from page 96 P&R)

Jones, Donald K., Supt., Munic. Water Filtration Plant, King & Penn Sts., Pottstown, Pa. (Apr. '57) *MRPD*

Kanen, John D., Township of Thorold, Allanburg, Ont. (Jan. '57)

Karasch, Kenneth A., Civ. Engr. III, Milwaukee, Wis. (Apr. '57) *MRPD*

Kauai County Waterworks Bd., Harold Ching, Box 146, Lijue, Kauai, Hawaii (Munic. Sv. Sub. Apr. '57)

Kaufman, A. A., City Engr., W. Charles St., Humboldt, Kan. (Apr. '57)

Keim, John, Munic. Water Plant Operator, Carmi, Ill. (Apr. '57) *MP*

Keith, J. Glenn, Sr. Clerk, Meter Dept., Water Dept., Denver, Colo. (Apr. '57) *MPD*

Kennett Square Water Dept., Robert F. Goddu, Chairman, Kennett Square Borough Council, Kennett Square, Pa. (Munic. Sv. Sub. Apr. '57) *MRPD*

Kinkade, George S., Jr., Office Mgr., W. Keansburg Water Co., M.B. Box 155 B., Keyport, N.J. (Apr. '57)

Kline, Kenneth Lee, Account Exec., W. L. Towne, 10 E. 40th St., New York, N.Y. (Apr. '57) *M*

Kneale, James Bradford, Asst. San. Engr., State Dept. of Health, Ohio Department Bldg., Columbus, Ohio (Apr. '57) *P*

Koike, Tsuneo, Civ. Engr., Hutchinson Sugar Co., Ltd., Naalehu, Hawaii (Apr. '57) *D*

Korab, Harry Edward, Tech. Director, American Bottlers of Carbonated Beverages, 1128—16th St., N.W., Washington 6, D.C. (Apr. '57) *P*

Lake, Milton H., Sales Engr., Armco Drainage & Metal Products of Canada, 37 Higgins Ave., Winnipeg, Man. (Jan. '57)

Lakin, Robert E., Jr.; *see* Boonsboro (Md.) Bd. of Water Comrs.

Lamar, City of, L. K. Christolear, Supt., 106 W. Elm, Lamar, Colo. (Munic. Sv. Sub. Apr. '57) *MRPD*

Laughlin, Angus A., Mgr. Manitoba Branch, Haddin, Davis & Brown Ltd., 201 Avenue Bldg., Winnipeg, Man. (Jan. '57)

Leach, Arthur H., Civ. Engr., 3880 Grotto Rd., Bridgeport, Mich. (Apr. '57) *MRD*

Lee, Robert E., Civ. Engr., 307 N. Broadway, Green Bay, Wis. (Apr. '57) *PD*

Lenain, Gus F., Water Supt., 518 S. Los Angeles St., Anaheim, Calif. (Apr. '57) *MRD*

Lester, Horace B., Cons. Engr., Lester Eng. Co., 514½ E. Amite St., Jackson, Miss. (Apr. '57) *RPD*

Light, Michael Abraham; *see* South Florida Public Service Co.

Lipinski, John W., Asst. Secy., Hackensack Water Co., 4100 Park Ave., Weehawken, N.J. (Apr. '57) *M*

Lowry, Emmett F., Asst. Water Engr., Munic. Water Dept., City Hall, Cajon & Vine, Redlands, Calif. (Apr. '57) *MRPD*

Lunetta, Anthony M., Hydr. Engr., Bergen County Eng. Dept., Hackensack, N.J. (Apr. '57) *R*

Lyons, W. Lloyd, Asst. Director of Operations, Water Dept., 2800 Airport Way, Seattle 4, Wash. (Apr. '57) *MRD*

Maness, John B., A.B.C. Water Co., Barling, Ark. (Apr. '57) *D*

Marley, Walter Martin, Sr. Engr., Metropolitan Water Dist. of Southern Calif., Rm. 1112, 306 W. 3rd St., Los Angeles, Calif. (Apr. '57) *MRPD*

Martin, Fred Ray, Pres., F. Ray Martin Engrs., Inc., 407 N. 8th St., St. Louis, Mo. (Apr. '57) *MRPD*

Martin, Henry L., Asst. Chemist, Water Dept., 577 Fairfield, N.E., Warren, Ohio (Apr. '57) *P*

(Continued on page 100 P&R)

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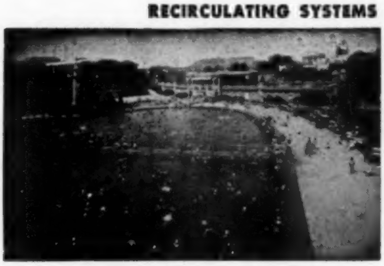

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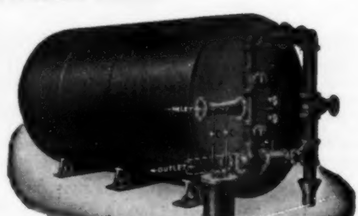

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(*Continued from page 98 P&R*)

Martin, Ignacio, Partner, Saenz-Cancio-Martin, Ave. de la Independencia 774, Ensanche del Vedado, Habana, Cuba (Apr. '57) *MRP*

Matthews, D. J., Pres., Matthews Const. Co., Ltd., 406 Princess Ave., London, Ont. (Apr. '57)

McCarthy, Richard James, Mgr., Pipelining Div., United Concrete Pipe Corp., Box 425, Baldwin Park, Calif. (Apr. '57) *F*

McLaughlin, Andrew T., Gen. Mgr., N. Marin County Water Dist., 834 Vallejo Ave., Novato, Calif. (Apr. '57) *M*

Mercer, Robert Tressler, Pres., Robert T. Mercer, Inc., 2121 Queen Anne Ave., Seattle 99, Wash. (Apr. '57) *PD*

Merwin, Daniel G., Admin. Engr., Water Works, Rm. 134, City Hall, Cincinnati 2, Ohio (Apr. '57) *M*

Metz, J. Robert, Authority Engr., Southeastern Oakland County Water Authority, Box 184, Royal Oak, Mich. (Apr. '57) *D*

Meyer, Robert E., Project Engr., Stevens & Thompson, 2234 S.W. 5th, Portland, Ore. (Apr. '57) *PD*

Miller, Calvin G.; *see* Graver Tank Mfg. Co. (Ind.)

Miller, Rube L., Repr., Worthington-Gamon Meter Div., 2616 Western Ave., Seattle, Wash. (Apr. '57) *D*

Moll, Lawrence A., Safety Supervisor, Water Dept., 2800 Airport Way, Seattle, Wash. (Apr. '57) *MD*

Montell, Bert S., Secy., Thermoplastics Pipe Div., Society of the Plastics Industry, Inc., 250 Park Ave., New York, N.Y. (Apr. '57) *D*

Morris, Reaves Floyd, Sales Engr., Wallace & Tiernan, Inc., 9702 Cloister Dr., Dallas 28, Calif. (Apr. '57) *PD*

Mosher, Lloyd William, Cons. Engr., 14050 W. McNichols Rd., Detroit 35, Mich. (Apr. '57) *MRPD*

National Tank Maintenance Corp., Allen Whitfield, Pres., 1617 Crocker St., Des Moines, Iowa (Assoc. M. Apr. '57)

Neher, S. S., Mgr., Water Dist., 12 N. Main St., East Wenatchee, Wash. (Apr. '57) *M*

Nelson, King Lee, Sales Repr., Johns-Manville Sales Corp., 301 Continental Oil Bldg., Denver, Colo. (Apr. '57) *D*

New Castle County Water Co., William H. Cox, Mgr., 85 Marrows Rd., Brookside Park, Newark, Del. (Corp. M. Apr. '57) *MRP*

Nord, Robert A., San. Engr., Bureau of San. Eng., State Bd. of Health, Jacksonville, Fla. (Apr. '57) *RPD*

Nunn, Herbert R., Asst. Director of Public Works, 716 Washington St., Vancouver, Wash. (Apr. '57) *RD*

O'Connor, John Thomas, Civ. Engr., Parsons, Brinckerhoff, Hall & MacDonald, 55 Broadway, New York, N.Y. (Apr. '57) *P*

Oklahoma State Bd. of Public Affairs, State Engr., Rm. 310, State Capitol Bldg., Oklahoma City, Okla. (Corp. M. Apr. '57) *R*

Orr, George W., Chief Draftsman, American Water Works Service Co., Inc., 3 Penn Center Plaza, Philadelphia, Pa. (Apr. '57) *MP*

Ort, Don R., Asst. San. Engr., State Bd. of Health, N.E. Branch Office, 1700 N. Harrison, Fort Wayne, Ind. (Apr. '57) *P*

Oslund, George R., Water Engr., Water Div., Spokane, Wash. (Apr. '57)

Palladino, Anthony J., San. Engr., 524 Oak St., Kalamazoo, Mich. (Apr. '57) *P*

Parker, Richard A.; *see* City of San Clemente (Calif.)

Parlett, Jack Knight, Mgr., Water Conditioning Div., Arundel Gas Co., Edgewater, Md. (Apr. '57) *RP*

Parnell, Roy O., Repr., Gamon Meter Div., Worthington Corp., 2616 Western Ave., Seattle, Wash. (Apr. '57) *D*

Pollard, Alva L., Jr., 1521 N.W. 45th St., Oklahoma City 18, Okla. (Apr. '57) *RPD*

Polster, Jerome I.; *see* Twinsburg Water Co.

Potter, Lehn John, Civ. Engr., Harold F. Hamill, Civ. Engr., 292 S. Main St., Plymouth, Mich. (Apr. '57) *RP*

Rash, Elbert G., City Supt., Box 259, Omak, Wash. (Apr. '57) *MRPD*

Ray, Marvin E., Public Works Director, Box 642 Modesto, Calif. (Apr. '57) *MRD*

Raymond, John Arthur, Field Engr., c/o Pitometer Assocs., 50 Church St., New York, N.Y. (Apr. '57) *MP*

Reis, Victor G., Johnstown Water Co., Locust St., Johnstown, Pa. (Apr. '57)

Rippe, Arthur Orrin, Repr., Johns-Manville Sales Corp., 301 Continental Oil Bldg., Denver, Col. (Apr. '57) *D*

Robertson, John Hayes, Design Engr., 47 Bldg. Eng. Dept., Dow Chem. Co., Midland, Mich. (Apr. '57) *RPD*

Robinson, William Harold, Dist. Engr., Surface Water Branch, US Geological Survey, Box 2052, Jackson 5, Miss. (Apr. '57) *R*

Roddy, James J., Asst. Utilities Engr., State Public Utilities Com., State Bldg., San Francisco, Calif. (Apr. '57)

Rodriguez, Raul, Chem. Engr., San. Eng. Branch, ERDL, Ft. Belvoir, Va. (Apr. '57) *RPD*

Round, Stuart W., Asst. Engr., Tonawanda, N.Y. (Apr. '57) *RPD*

Rucker, C. V., Product Engr., James B. Clow & Sons, Inc., Coshocton, Ohio (Apr. '57) *D*

Russells Point Waterworks, Thomas P. Golden, Supt., Box 394, Russels Point, Ohio (Corp. M. Apr. '57) *MD*

Sabine River Works of E. I. DuPont De Nemours & Co., J. B. Coghill, Box 2027, Orange, Tex. (Corp. M. Apr. '57)

San Clemente, City of, Richard A. Parker, Supt., Water & Sanitation, 408 N. El Camino Rd., San Clemente, Calif. (Corp. M. Apr. '57)

Sandoval, Hernan, Supt. of Munic. Water Works, Apdo. Aereo 1300, Cali, Columbia (Apr. '57) *RPD*

Santa Maria, City of, Jesse D. Smith, Water Production Foreman, 110 E. Cook St., Santa Maria, Calif. (Munic. Sv. Sub. Apr. '57)

Schaefer, Charles A., Sr. Engr., Water Supply Sec., Div. of San. Eng., State Dept. of Health, 410 E. 5th, Austin, Tex. (Apr. '57) *MRPD*

Schmitz, Albert L., Const. Engr., Water Works, City Hall, Milwaukee, Wis. (Apr. '57) *MD*

Schuchs, Eugene B., Foreman of Supply, Baton Rouge Water Works Co., Drawer 2391, Baton Rouge, La. (Apr. '57) *RP*

Scribner, Charles B., Lab. Asst., Water Dept., Denver, Colo. (Apr. '57) *P*

Secrest, William G., Supervisor, Water Div., 730 E. Delhi Rd., Santa Ana, Calif. (Apr. '57) *M*

Seeterlin, James E., Clerk, Waterford Township, 4995 W. Huron, Pontiac, Mich. (Apr. '57) *MR*

Sharpe, W. L., City Engr., Weyburn, Sask. (Apr. '57)

Shikarah, A. Razak; *see* Iraq Directorate General of Municipalities

Smith, George V., Supt., Water Dept., 217 S.E. 4th St., College Place, Wash. (Apr. '57) *MD*

Smith, Jesse D.; *see* City of Santa Maria (Calif.)

Smith, Milton M., Distr. Foreman, Water Div., 5228 S. M St., Tacoma, Wash. (Apr. '57)

Sonoma Water & Irrigation Co., Helmut H. Golitz, Gen. Mgr., Box 278, El Verano, Calif. (Corp. M. Apr. '57) *MPD*

South Florida Public Service Co., Michael Abraham Light, Vice-Pres., 1491 N.W. 20th St., Miami, Fla. (Corp. M. Apr. '57) *MD*

Stafford, Everett Bates, Director, Public Works, Statesville, N.C. (Apr. '57) *MRPD*

Stell, Clyde Benson, Resident Engr., Freese & Nichols, 407 Danciger Bldg., Fort Worth, Tex. (Apr. '57) *PD*

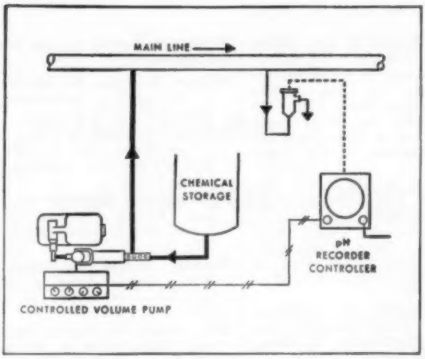
Stephenson, J. Leo, Water Works Supt., Wheatland, Ind. (Apr. '57) *MPD*

Stinson, Don L., John Wiley Jones Co., Box 29, Wyandotte, Mich. (Apr. '57) *P*

Stockman, Richard C., Mgr., Berkeley Office, John A. Carollo, 2168 Shattuck Ave., Berkeley 4, Calif. (Apr. '57) *RPD*

Storke, Charles B., Asst. Operator, Water Dept., Brigantine, N.J. (Apr. '57) *M*

(*Continued on page 102 P&R*)



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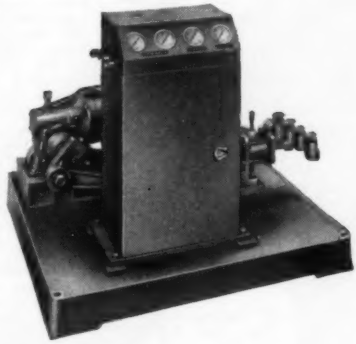

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Stormont, Glenn I., Elec. Engr., Dept. of Water Supply, 735 Randolph, Detroit 26, Mich. (Apr. '57) *PD*

Sudderth, Earle W., Owner, Koch & Fowler, 3900 Lemmon Ave., Dallas, Tex. (Apr. '57) *PD*

Swartz, Jacque W., Supt. of Pumping & Maintenance, Hackensack Water Co., 4100 Park Ave., Weehawken, N.J. (Apr. '57) *M*

Taylor, L. R., Waterworks Supt., 4639—47th St., Red Deer, Alta. (Jan. '57)

Taylor, William H., Pres., Taylor & Hoover, Inc., Box 325 E., Pasadena, Calif. (Apr. '57)

Terrel, R. A., Water Supt., Robert's Creek Water Dist., Rte. 1, Box 1160, Roseburg, Ore. (Apr. '57) *MRPD*

Thomas, Henry F., Jr., San. Sales Engr., Dorr-Oliver, Inc., Barry Pl., Stamford, Conn. (Jr. M. Apr. '57) *PD*

Thompson, Joseph, Eastern Mgr., Illinois Water Treatment Co., 840 Cedar St., Rockford, Ill. (Apr. '57) *P*

Tooley, Lowell James, Asst. Village Mgr., Village Hall, Scarsdale, N.Y. (Apr. '57) *MD*

Trout, John W., Jr.; *see* City of Haysville (Kan.)

Twinsburg Water Co., Jerome I. Polster, Pres., Rm. 605, Society for Savings Bldg., Cleveland, Ohio (Corp. M. '57) *MRD*

Vlescas, A. H.; *see* El Paso (Tex.) Natural Gas Co.

Wascher, Edwin, Supt., Wenatchee Valley Water Co., Rte. 2, Box 2480, Wenatchee, Wash. (Apr. '57)

Weaver, H. B., Jr., Sales Engr., James B. Clow & Sons, Inc., Box 2542, Birmingham 2, Ala. (Apr. '57) *PD*

Weir, Frank F., Mgr., T. McAvito & Sons, Ltd., 171 Market St., E., Winnipeg, Man. (Apr. '57)

Weiss, Charles M., Assoc. Prof. of San. Science, Dept. of San. Eng., School of Public Health, Univ. of North Carolina, Chapel Hill, N.C. (Apr. '57) *RP*

Wharton, Jimmy L., Salesman, Pipe Div., Johns-Manville Sales Corp., 301 Continental Oil Bldg., Denver, Colo. (Apr. '57) *RD*

Whelen, D. A., Partner, Associated Eng. Services, 2256 W. 12th Ave., Vancouver, B. C. (Jan. '57) *MRPD*

Whitfield, Allen; *see* National Tank Maintenance Corp. (Iowa)

Wiedman, John Herman, Utilities & Transportation Officer, US Naval Station, Key West, Fla. (Apr. '57) *MRPD*

Wiese, Herman Benjamin, Supt., Public Works, Collinsville, Ill. (Apr. '57) *M*

Wilkinson, David G., Sales Engr., The Foxboro Co., 2307 E. 8th St., Los Angeles 21, Calif. (Apr. '57) *PD*

Williams, James A.; *see* Village of Glencoe (Ill.)

Wilson, Douglas R., Munic. Engr., 51 Shelley St., Georgetown, Ont. (Jan. '57)

Wilson, Ronald V., Supt., King County Water Dist. No. 97, 15450 Lake Hills Blvd., Bellevue, Wash. (Apr. '57) *M*

Wissmiller, Edward L., Tech. Eng., Remote Recorder Co., 2012 Lowell St., Saginaw, Mich. (Apr. '57) *D*

Woods, James Beverley, Sales Mgr., Canada Valve & Hydrant Co., Ltd., 44 Holme St., Brantford, Ont. (Jan. '57) *PD*

Yee, Journ T., Project Mgr., Harland Bartholomew & Assocs., 125 Bethel St., Honolulu, Hawaii (Apr. '57) *RPD*

Yocum, Frederick H., Pres., Yocum & Goode, Inc., 420 Lexington Ave., New York, N.Y. (Apr. '57)

Zander, Paul M., Cons. Engr., Paul Zander & Co., 509 E. Markham, Little Rock, Ark. (Apr. '57) *MRPD*

Zeitler, Albert, Operator, Public Water Treatment Plant, 324 Humest, Allenhurst, N.J. (Apr. '57) *P*

Zintek, William, Water Plant Supt., Lewiston, Idaho (Apr. '57) *RP*

Zirul, M. L.; *see* British Columbia Water Rights Branch, Dept. of Lands & Forests

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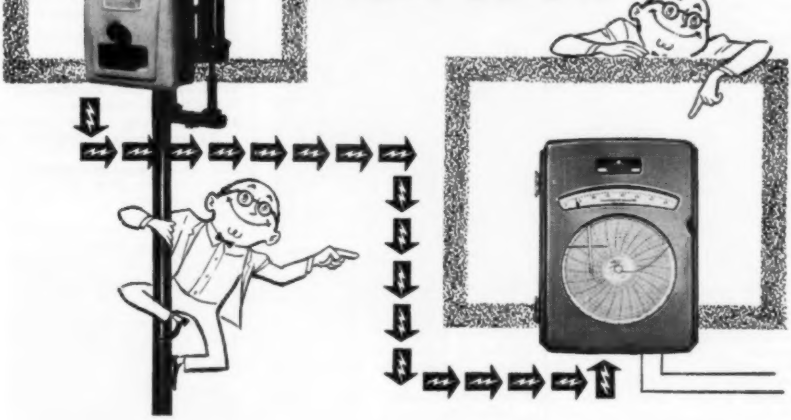

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Trinity Valley Iron & Steel Co.
R. D. Wood Co.
Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.
Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.
Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.
Valves, Detector Check:
Hersey Mfg. Co.
Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.
Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.
Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.
Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.
Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.
Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.
Water Softening Plants; see Softeners
Water Supply Contractors:
Layne & Bowler, Inc.
Water Testing Apparatus:
Wallace & Tiernan Inc.
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Well Drilling Contractors:
Layne & Bowler, Inc.
Wrenches, Ratchet:
Dresser Mfg. Div.
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.